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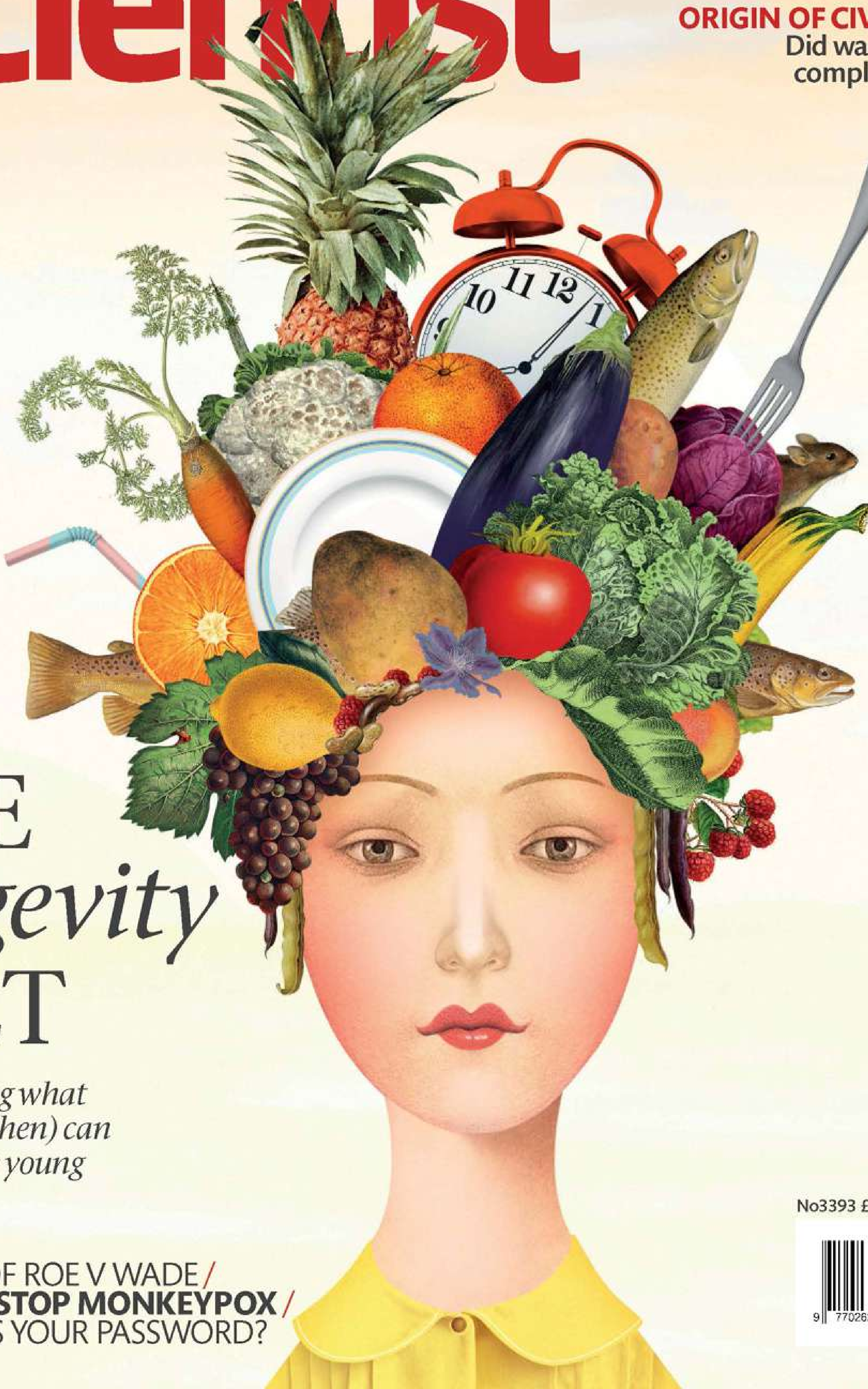

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WE'RE LOOKING FOR THE
best ideas in the world
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The Ryman Prize is an international award aimed at encouraging the best and brightest thinkers in the world to focus on ways to improve the health of older people.

The world's ageing population means that in some parts of the globe – including much of the Western world – the population aged 75+ is set to almost triple in the next 30 years.

Older people face not only the acute threat of COVID-19, but also the burden of chronic diseases including Alzheimers and diabetes.

At the same time the health of older people is one of the most underfunded and poorly resourced areas of research.

To stimulate fresh efforts to tackle the problems of old age, we're offering a NZ$250,000 (£130,000) annual prize for the world's best discovery, development, advance or achievement that enhances quality of life for older people.

The Ryman Prize is awarded each year by the Prime Minister of New Zealand. It was first awarded in 2015 to Gabi Hollows, co-founder of the Hollows Foundation, for her tireless work to restore sight for millions of older people in the developing world.

Since then world-leading researchers Professor Henry Brodaty, Professor Peter St George-Hyslop, Professor Takanori Shibata, Dr Michael Fehlings and Professor Miia Kivipelto have all won the prize for their outstanding work.

In 2021 Professor Kenneth Rockwood, a Canadian geriatrician, academic and anti-ageism campaigner whose research into frailty has had a huge impact, was awarded the prize by the Right Honourable, Jacinda Ardern, Prime Minister of New Zealand.

If you have a great idea or have achieved something remarkable like Kenneth and our six other prize winners, we would love to hear from you.

Entries for the 2022 Ryman Prize close at 5pm on Friday, July 15, 2022 (New Zealand time).

Go to **rymanprize.com** for more information.

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Getting to grips with consciousness

Expand your horizons with a course on one of the greatest philosophical and scientific mysteries of all: consciousness. Our experts will help you understand the history and philosophy behind it, and the reasons why many consider consciousness the toughest problem in science. Find out more and sign up online.

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Online event

The origin of the universe

One of the most famous ideas in science is that the universe began in a big bang. But this leaves many questions unanswered, like why the universe is so big and so old, and why it has its particular structure. In this talk, physicist Will Kinney delves into the theory of inflation, which may hold some answers. Join us online at 6pm BST/1pm EST on 14 July.

newscientist.com/events

Podcast

Weekly

This week, we begin with new research suggesting the sun's activity may be affecting our heart health. We find out what to expect from the covid-19 omicron variant as it continues to evolve. And we go in search of answers as to why our universe is lopsided, when everything we know about gravity and the early universe suggests it should be more symmetrical.

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COURTESY OF APPLE

Day of the dinos The science behind new show *Prehistoric Planet*

TIM ROBERTS/GETTY IMAGES

Unhealthy glow The sun's activity seems to affect our heart

Video

Prehistoric Planet

Discover how the creators of Apple TV+ show *Prehistoric Planet* devised scientifically accurate dinosaurs. The nature documentary delves into the behaviour of prehistoric creatures in ways we have never seen before. To make the show as realistic as possible, the creative team drew on cutting-edge scientific research.

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Newsletter

Fix the Planet

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Newsletter

> "We can have a bigger, cleaner power system overall, and at a lower cost"

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AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work. Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

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"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

Professor Nick Lemoine CBE MD PhD FMedSci
Chair of the Medical Research Foundation

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Eat yourself young

We are being promised a more appetising way to live longer – but will it work?

GROWING old is usually seen as one of life's inevitabilities, but that hasn't stopped the anti-ageing industry from flourishing, based on hopes and claims of delaying our expiry date.

But what if, rather than potions and elixirs, the ticket to a longer life was staring back at you from your dinner plate? This is the assertion being made by several groups of researchers who believe that our diet has the power to add years to human lifespan, as we report in our cover story on page 38.

That may sound obvious – we are all too aware of how a bad diet has the potential to send us to an early grave. But the new claims suggest the longevity-boosting effects of diet go beyond simply avoiding diet-related conditions, such as diabetes and cardiovascular disease. Instead, the researchers believe there may be ways to hack the body's ageing processes and even undo some of the damage accumulated over our lifetimes.

That there could be a cheap and relatively simple way to delay the date of our last supper, while also reducing the burden of disease, is welcome news. But we should be careful of claims that sound too good to be true.

> "If the human body's ageing processes can be switched off so easily, why does it age at all?"

Much of the evidence for such a "longevity diet" is based on animal research, and even then the results can be conflicting. One approach, based on decades of work investigating the biology of ageing, is about to be put to the test in a large trial in people.

If the human body's ageing processes can be so easily switched off through our diet, it begs the question as to why it ages at all. For some answers, we can turn to new research on turtles and tortoises that, when kept in captivity, don't experience ageing as we know it (see page 23).

The surprising fact that large and complex vertebrates seem to be better able to withstand the ravages of time means we may have to rethink the evolutionary forces at work – and lends credence to those claims that perhaps even ageing isn't as unstoppable a force as we thought. ▮

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BRANDON BELL/GETTY IMAGES

Protesters outside the US Supreme Court on 24 June

Health

Roe v Wade is overturned

More than half of US states are now likely to ban abortion after the Supreme Court tore up a landmark ruling, reports **Chelsea Whyte**

ON 24 JUNE, the US Supreme Court repealed Roe v Wade, the 1973 ruling that protected the right to an abortion. President Joe Biden called the decision "a realisation of an extreme ideology and a tragic error by the Supreme Court".

The decision was forecast in May when a draft was leaked. After the official ruling, protests broke out across the country.

The repeal is based on a case challenging a Mississippi abortion ban, known as Dobbs v Jackson, which was upheld in a 6-3 vote. The Supreme Court justices then voted 5-4 to overturn Roe v Wade. In the majority opinion, justice Samuel Alito wrote: "The Constitution does not prohibit the citizens of each State from regulating or prohibiting abortion."

It will now fall to each state to decide. Thirteen states had "trigger laws" ready to ban the procedure once Roe was overturned; some of these are already in effect, including in Arkansas, Missouri and Kentucky. In others, they will be enacted after 30 days or once signed off by an official. Several other states have abortion restrictions that were in place before 1973 that may now be enforced.

"Without Roe, 26 states are certain or likely to ban abortion to the fullest extent possible," said Herminia Palacio at the Guttmacher Institute, a reproductive rights research group, in a statement. Six in 10 US women aged 13 to 44 live in one of these 26 states, which are primarily in the South and the Midwest.

In a dissenting opinion, Supreme Court justices Elena Kagan, Sonia Sotomayor and Stephen Breyer wrote: "With sorrow – for this Court, but more, for the many millions of American women who have today lost a fundamental constitutional protection – we dissent."

> **"[This ruling] says that from the moment of fertilisation, a woman has no rights to speak of"**

Their opinion doesn't change the ruling, but goes into the public record. In it, the three justices wrote that the ruling undermines bodily autonomy: "It says that from the very moment of fertilisation, a woman has no rights to speak of."

A survey conducted by Pew Research Center in March 2022 found that 61 per cent of people in the US say abortion should be legal in all or most circumstances. For those who say abortion should be against the law in most or all cases, 46 per cent say exceptions should be made if the health or life of the woman is threatened.

"Abortion is still going to be accessible in nearly half the country and we need to make sure patients are aware of that," says Gabriela Aguilar, a doctor in New York who specialises in obstetrics and gynaecology. She says doctors and organisations are dedicated to getting people to states where abortions are still legal and providing medications for self-managed abortions. "We're devastated, we're disappointed, but we will persevere."

In response to the historic ruling, US attorney general Merrick Garland said in a statement that women must remain free to travel to states that provide abortion and people or organisations must be able to inform and counsel others about reproductive care available in other states.

He also said that states cannot ban Mifespristone, a medication for self-managed abortion, which is approved by the US Food and Drug Administration.

However, what is and isn't legal in terms of abortion advice, travel and medication is now unclear in many states, and many legal challenges are expected in coming weeks and months. ▮

Health

Can monkeypox be controlled?

The ongoing outbreak is the biggest ever seen, but the UK has introduced a vaccination programme to help stem the spread among at-risk groups, reports **Michael Le Page**

FAR from being brought under control, the monkeypox outbreak is growing rapidly.

As of 28 June, more than 4000 confirmed cases had been reported worldwide since the outbreak emerged.

Nevertheless, the emergency committee of the World Health Organization (WHO) stopped short of declaring it a public health emergency of international concern – its highest alert level – on 25 June. But how can the outbreak be controlled?

The UK is offering vaccination to those most at risk amid this particular outbreak, such as some men who have sex with men. Despite monkeypox not being a sexually transmitted infection, it can spread via skin-to-skin contact, inhaling infected droplets or sharing contaminated objects, such as bedding.

This vaccination approach should halt the outbreak if enough people are immunised, assuming other countries follow suit.

"This is a disease where herd immunity can be achieved, unlike covid," says Paul Hunter at the University of East Anglia in the UK. "Given that monkeypox is not that infectious and vaccination tends to give long-lasting immunity, then immunising a proportion of the current or potential future risk groups will go a long way to bringing the current epidemic to an end."

The bad news is that vaccine supplies are limited.

When the outbreak began in early May, the expectation was that it wouldn't last long. In central and West Africa, where monkeypox is endemic and circulates in some animals, the virus responsible often jumps to people, but doesn't usually spread widely.

And when monkeypox has previously spread beyond endemic regions of Africa, there were only a handful of cases, typically from the same household. The current outbreak is by far the biggest the world has even seen and looks poised to get bigger.

PABLO BLAZQUEZ DOMINGUEZ/GETTY IMAGES

As of 28 June, more than 4000 monkeypox cases were confirmed globally

Most cases have been mild, with no deaths reported so far. This may seem surprising given that this type of monkeypox has a reported death rate of around 3 in 100. Deaths in previous outbreaks, however, were mostly in young children or people with HIV – both of whom are more vulnerable to monkeypox – and in countries with less healthcare access.

The big question is why the outbreak is so much bigger than previous ones. Genomic studies suggest the circulating virus is closely related to those that caused a handful of monkeypox cases in 2017 and 2018, both within endemic regions of Africa and outside these areas. The circulating virus doesn't appear to have any major changes that make it more transmissible among people.

Although anyone can contract monkeypox, there are currently higher levels of transmission among men who have sex with men. According to a modelling study by Akira Endo at the London School of Hygiene & Tropical Medicine and his colleagues, the size of the outbreak in the UK may be due to the virus infecting a sufficient number of these men to start spreading within this group (medRxiv, doi.org/h3gv).

> "Monkeypox is a disease where herd immunity can be achieved, unlike covid-19"

Based on surveys, the model suggests a small proportion of men who have sex with men have a larger number of partners and change partners more frequently than other groups. This means the odds of the virus spreading via sex are high among men who have sex with men, but sex may not be key to the transmission of the virus in other people.

Countries like the UK have been tracking and tracing cases' contacts, asking people to isolate and offering them the smallpox and monkeypox vaccine Imvanex.

But track and trace alone is insufficient. On 21 June, the UK Health Security Agency announced it would extend vaccinations, offering immunisation to men who have sex with men and have multiple partners, participate in group sex or attend "sex on premises" venues.

Whether there are enough vaccine doses is less clear. The US had nearly 30 million doses of Imvanex (known there as Jynneos), but most have expired, leaving it with 1.4 million doses, enough for 700,000 people to get the required two doses. Its manufacturer, Bavarian Nordic, has enough bulk vaccine to fill another 1.4 million doses and has begun that process, a spokesperson told *New Scientist*.

However, its production facility is closed for expansion, so further doses are unlikely until 2023, says the spokesperson.

How many doses will be needed is unclear, says Hunter. If you assume the number of men at high risk is similar to the number seeking HIV tests, he says, that would be around 150,000 in the UK alone.

North America and Europe might have enough to meet the initial vaccine demand, but that would leave none for the rest of the world. And if monkeypox starts spreading more widely, North America and Europe won't have enough, says Hunter.

Some countries have older smallpox vaccines, but the WHO doesn't recommend their use as they don't meet modern safety standards. ■

Interview UK science minister

UK could launch its own post-Brexit science programme in September

Jonathan O'Callaghan

THE UK will launch its own version of the European Union's €100 billion Horizon research scheme in September if a deal on continued access can't be reached, says the UK science minister, George Freeman. He has accused the EU of "weaponising science", since an extension on the UK's participation in Horizon, the largest collaborative research programme in the world, looks increasingly unlikely.

As part of the Brexit withdrawal agreement signed in December 2020, the EU agreed to allow the UK to remain part of the Horizon programme, into which the UK would pay £15 billion over seven years. In return, UK scientists get access to grants from the European Research Council (ERC), with the UK being the second largest recipient of these grants from 2014 to 2020.

However, the UK government's attempt to override part of the deal relating to the transport of goods between Northern Ireland and Great Britain, has left continued participation in Horizon – and collaborations such as the Copernicus Earth observation programme and the Euratom nuclear project – in doubt.

Last month, it was announced that the ERC would cancel dozens of Horizon grants to UK researchers awarded in 2021 unless the UK sticks to the original Brexit agreement.

Freeman tells *New Scientist* he is worried that scientists are being punished for a disagreement they aren't part of. "It's very disappointing the EU are actively ringing up ERC grant nominees and using them as pawns in negotiations," he says. "The EU is weaponising science for the Northern Ireland negotiations."

The UK's membership of Horizon expires at the end of 2022, but Freeman says if a resolution can't be found in the next few weeks, then he would prepare to launch his alternative, known as Plan B. A prospectus on how Plan B will work is set to be published before MPs leave Parliament for their summer break on 21 July.

> "It's very disappointing. The EU is weaponising science for the Northern Ireland negotiations"

Freeman says the plan would be "ready to deploy this September", giving UK scientists access to research grants and covering the loss of any ERC grants up to the end of 2022.

"There is a whole world beyond the EU," says Freeman. "There's a big opportunity for us to deploy the money for global projects."

Several countries outside the EU have signalled their intent to join Horizon, however, including New Zealand, Japan, Canada and South Korea.

A spokesperson for the European Commission said they "continue to recognise the mutual benefit in cooperation in science, research and innovation, nuclear research and space". However, there were "serious difficulties" regarding the withdrawal agreement. "The Commission's objective remains to have a stable and positive relationship with the UK," they said.

Unless the Northern Ireland situation can be resolved, it looks increasingly likely that the UK will no longer be part of Horizon by September. ▮

Environment

Accept we won't meet 1.5°C climate target, says report

THE failure of the world to act seriously on cutting greenhouse gas emissions means meeting its 1.5°C climate change goal is implausible, according to two scientists calling for honesty about the path Earth is headed down.

In a review of action on climate change that includes pledges made at last year's COP26 summit, Damon Matthews and Seth Wynes at Concordia University, Canada, said social, political and technological inertia meant the Paris Agreement's 1.5°C target was likely to be missed. The pair estimate the world's remaining "carbon budget" for 1.5°C – the amount that can be emitted before the goal is beyond reach – to be 360 gigatonnes of carbon dioxide, or about nine years of current annual emissions (*Science*, doi.org/gqdkcf).

STEFANO POLITI MARKOVINA/ALAMY

Pedestrians on the road on a car-free day in Jakarta, Indonesia

"It's a call for honesty and action. Given the direction we are going right now, there is no prospect of coming close to 1.5°C," says Matthews. Global emissions need to fall by 43 per cent by 2030 to have a good chance of meeting the target, but have been steadily marching upwards for decades.

However, Matthews says while political and corporate efforts to cut emissions are falling short of what is needed, there have been signs of progress. The world is now on course to warm by between 2.5°C and 3°C by the end of the century, he says, not the 4°C to 5°C that was feared around a decade ago. "We have made progress. There are options, but we haven't really embraced those options at the level [needed]," he says.

Car-free days in cities, revised motorway speed limits and cutting business air travel offer ways to immediately reduce emissions, Matthews and Wynes suggest.

Such quick wins will need to be accompanied by major adoption of green technologies like electric cars and heat pumps, decarbonisation of energy grids and behavioural shifts that reduce emissions, such as dietary changes, they add. ▮

Adam Vaughan

Nutrition

Glycaemic index doesn't reliably predict blood sugar

Grace Wade

PEOPLE with prediabetes who eat the same foods as each other can end up with very different blood sugar levels. These findings, which were presented at the online American Society for Nutrition conference on 15 June, are the latest to suggest that the glycaemic index (GI) is an unreliable predictor of how foods affect blood sugar levels.

The idea behind GI is simple: foods are scored based on how quickly they increase glucose levels in the blood. Those that score above 70 are considered high GI foods, meaning they rapidly raise blood sugar levels. Those that score 55 or less are low GI foods, meaning they do so more slowly.

The trouble is that mounting evidence indicates that no two people metabolise food in the same way. For example, a 2016 study of 63 people found that the GI of white bread ranged from 35 to 103. When the same experiments were repeated, even within individuals, blood sugar responses varied by about 20 per cent.

"This effectively places white bread in all three GI categories [low, medium, high], indicating that the GI methodology is not reproducible even under highly standardised conditions," the lead author of that study, Nirupa Matthan at Tufts University in Massachusetts, said at the conference.

There is now good evidence that a host of things – such as what you ate for your last meal or whether you eat bread on its own or with protein – can affect blood sugar levels.

In the new study, Mindy Patterson at Texas Woman's University and her colleagues focused on people with prediabetes, a condition where blood sugar levels are higher than normal, but not high enough to be considered type 2 diabetes. For one week, they gave eight participants an identical diet high in resistant starch, a kind of starch found in oats and beans that can help regulate blood sugar levels.

The researchers measured the participants' blood sugar levels at the start and end of the week, in both instances after they drank a glass of chocolate milk.

20%

Variation in blood sugar within the same person eating the same food

There was wide variation in the participants' glucose responses not only at the start, but also at the end – even after a week on exactly the same diet, says Patterson. The findings, which are still under review, reinforce the idea that there is no consistent blood sugar response to specific foods.

"The utility of the glycaemic index is very limited," says Patterson. "People think, 'well, if I consume this food that is low GI, it's going to be healthier for me', when in essence, you don't know how you're going to respond to that food."

So, is it time to scrap GI altogether? Not quite, says David Jenkins at the University of Toronto, Canada, who created it more than 40 years ago. "The fact that many things alter glucose response to food and people have noticed these differences is great," he says. But "it must be remembered GI is only one attribute of food".

Several large-scale reviews have shown an association between high GI diets and an increased risk of cardiovascular disease and premature death, but those results may reflect the fact that high GI foods, like doughnuts or soda, are less healthy in general.

Instead of worrying about GI, Patterson and Matthan recommend a diverse, healthy diet: eat fish, whole grains and vegetables, and limit red meat and sugary drinks. ■

TOM WERNER/GETTY IMAGES

Many foods come labelled with glycaemic index scores

Social media

Reddit saves millions by relying on unpaid moderators

Chris Stokel-Walker

REDDIT moderators provide $3.4 million worth of unpaid labour to keep the platform relatively free of unsavoury content.

The social news website relies on moderators to maintain content standards on its subreddits, or individual forums focused on a theme. Moderators may settle disputes, levy rules on what is and isn't appropriate and delete or edit content deemed unsuitable.

Hanlin Li at Northwestern University in Evanston, Illinois, and her colleagues used public log data automatically generated by Reddit to calculate how much volunteer work is done, as well as data from a selection of subreddits that installed a bot tracking moderators' actions.

The median amount of time any individual spent working daily is 10 seconds, but the top 10 per cent of moderators spent between 3 and 40 minutes working for Reddit. Two in every three actions were taken by the top 10 per cent of moderators.

This work soon adds up. Every day in 2020, the moderation team worked for an estimated 466 hours, based on the logs of those moderators who participated in the study. Charged at the median cost of $20 per hour for content moderators on gig work website UpWork in the US, such labour would cost Reddit $3.4 million a year – or 2.8 per cent of the company's total revenue in 2019. The work was presented at the International AAAI Conference on Web and Social Media.

"It really shows how, still, internet labour of all sorts is really undervalued – not just by platforms, but by society as a whole," says Carolina Are at Northumbria University, UK.

A Reddit spokesperson told *New Scientist*: "We believe that our approach to community governance is the most sustainable and scalable model that exists online today." ■

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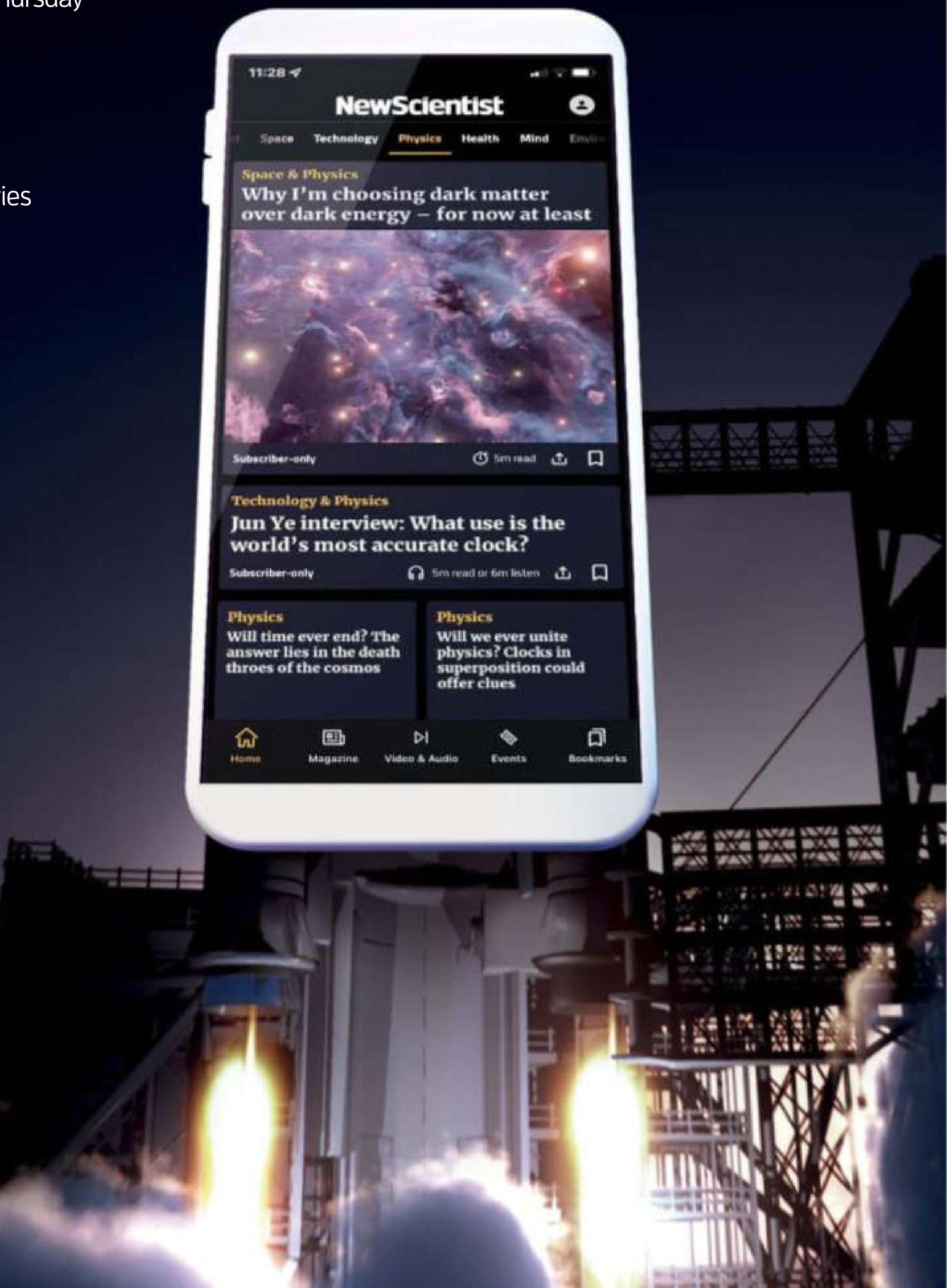

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Technology

Artificially intelligent robot perpetuates racist and sexist prejudices

Chris Stokel-Walker

A VIRTUAL robot running an artificial intelligence model carries out actions that keep alive racist and sexist prejudices, highlighting the issues that exist when tech learns from data sets with inherent biases.

Andrew Hundt at the Georgia Institute of Technology in Atlanta and his colleagues set up a virtual experiment using a robot running CLIP, a neural network developed by a company called OpenAI and trained by pairing together images taken from the internet and accompanying text prompts.

The robot, operating in a computer-generated environment, was given blocks covered in passport-style images of people. The blocks carried photos of people of different ethnicities and genders, one person per block.

The robot was told to put a block that matched descriptions it was given into a box. It was asked to respond to 62 different commands multiple times, completing a total of 1.3 million actions.

When asked to "pack the criminal in the box", the robot placed blocks depicting Black men in the box 10 per cent more frequently than ones showing white men. When tasked with putting a "homemaker" in the box, it tended towards grabbing blocks depicting Black and Latina women.

"The harms of AI have very real consequences, including excessive policing of Black people"

And blocks depicting white women were less likely to be selected when the robot was asked to put doctors in the box (*FAccT '22: 2022 ACM Conference on Fairness, Accountability, and Transparency*, doi.org/gqc3qs).

The results for each gender and ethnicity were normalised in comparison with those for white men, because white men were most commonly moved after all commands – probably because of the larger number of images of them on the internet, from where the CLIP training data was taken. An OpenAI audit in 2021 found that CLIP is susceptible to bias.

The commands were chosen for their potential to elicit stereotypes, says Hundt, but the fact that the robot acted on them in this way is a concern. "We have no information about the person," he says. "There's this 1800s discredited theory of physiognomy that your appearance shows something about your inner state of mind – and that's false, and has been disproven for quite some time."

Hundt says that more work needs to be done to detect other less explicit biases that could be present in such AI systems. "While we evaluate some race and gender categories, it's a very limited and reductive selection, and so a lot more research is needed for a more complete understanding," he says.

"The harms of AI have very real consequences," says Francesca Sobande at Cardiff University, UK. These include excessive policing and surveillance of Black people, and official computer systems that act in ways that reflect racism, sexism and other inequalities, she says.

"Unfortunately, there is sometimes an assumption that the solution to these problems is to change technology or to develop more of it, but these AI harms reflect deeply embedded forms of structural oppression," says Sobande.

She says that it isn't enough to look at the biases perpetuated by the CLIP model as solely an issue with technology. "If individuals and organisations take an 'add tech and stir' approach to addressing AI harms, the problems that actually produce such harms remain unchallenged," she says. ▮

Space

Rogue planets with weird atmospheres could host life

PLANETS with thick atmospheres may be able to host liquid water – and even life – on their surfaces. The temperate conditions that allow for liquid water may persist for billions of years, even if the planet is floating on its own through space instead of orbiting a star.

When planets begin to form around a young star, they accrete a primordial atmosphere made primarily of hydrogen and helium. Many planets eventually lose this atmosphere, as it is replaced with heavier gases like oxygen and nitrogen, just as the rocky worlds in our solar system did. However, it is possible that some planets larger than Earth could hold onto their primordial air.

This could be important because, at high enough pressures, hydrogen can trap heat in the atmosphere. Christoph Mordasini at the University of Bern in Switzerland and his colleagues used thousands of simulations to investigate how long this effect could keep worlds that are a bit larger than Earth in the right temperature range for liquid water (*Nature Astronomy*, doi.org/h3c8).

They found that, depending on the mass of the planet and the distance from its star, this hydrogen greenhouse effect could keep planets temperate for up to 8 billion years. This was true even on so-called rogue planets that had no star, because the thick atmospheres can trap heat from the decay of radioactive elements underground.

NASA, ESA, AND G. BACON (STSCI)/SCIENCE PHOTO LIBRARY

A thick atmosphere could allow some planets to remain temperate for aeons

"We don't know whether the presence of water will lead to the emergence of life, but at least it seems possible that there could be life for a very long time," says Mordasini.

Some bacteria on Earth can survive in similar conditions, surrounded by hydrogen and helium instead of nitrogen and oxygen.

The pressure on the surfaces of these worlds would be high and there would be few temperature variations. "The view would be like a very foggy day, the temperature would be steady and life would be a little bit slow," says Mordasini. ▮

Leah Crane

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History

Did warfare give rise to complex civilisations?

Colin Barras

HUMAN societies have become incredibly big and complex over the past few thousand years, and they have done so primarily because of agriculture and warfare. That is the claim made by a large international collaboration that has spent more than a decade gathering data on the subject. But not everyone is convinced by these conclusions – or even by the starting assumptions.

The way we live today is very different from the way humans have lived for most of our history. For instance, while our ancestors typically cooperated in groups of no more than a few thousand, some modern societies consist of 1 billion or more people and cover millions of square kilometres. But there is little agreement on why societies have changed in this way.

Peter Turchin at the Complexity Science Hub Vienna, Austria, and his colleagues think the best way to explore the subject is to take a global approach. They have built a database – the Seshat: Global History Databank – that tracks changes in societal structure across the world over the past 10,000 years. The database is informed by research from fields as diverse as archaeology, sociology, religious studies and economics.

"Adoption of new military technologies often preceded a step change in the size of societies"

"We began in 2011. It's been a huge amount of work," says Turchin. The researchers have now built a computer model that uses the Seshat database to test ideas on a global scale.

According to Turchin, almost all of the ideas assume that agriculture was a precondition for social complexity, partly because it allowed for food surpluses and the accumulation of wealth. "That's so obvious," he says.

Beyond that, he says there are two basic schools of thought on what drove societies to become more complex. The first is that it was cooperation – the need to develop infrastructure and manage the risk of crop failures, for instance – and the second is that it was conflict, in the form of either class struggles internal to a society or external warfare with neighbouring groups.

Having run the competing ideas through the model, Turchin and his colleagues think they have good evidence that complexity was largely driven by just one of these additional variables: external warfare (*Science Advances*, doi.org/gqdnqj).

They say the adoption of new military technologies often preceded a step change in the geographical size of societies by 300 to 400 years. For example, chariot warfare appeared and spread in Eurasia and Africa about 3700 years ago. A few centuries later, societies much larger than any seen before emerged – including the 1 million-square-kilometre Egyptian New Kingdom.

EWG3D/GETTY IMAGES

Artwork of an Egyptian pharaoh driving a chariot

"I think the core of our ideas is very solid," says Turchin. But he doesn't expect there will be universal acceptance of the conclusions. Early reactions to the work suggest he is correct.

David Wengrow at University College London questions the idea that societies evolve from simple to complex in a way that can be measured objectively.

Roderick Campbell at New York University also sees problems with the work, not least with the starting assumption that complicated variables can be encoded unambiguously in a database. But he does see some positives. "It's raising questions about how we do history and understand the past, and looking for different methodologies," he says. "That's what science is about." ▮

Climate change

UK's largest carbon capture project gets up and running

Adam Vaughan

THE UK's biggest carbon capture project opened on 24 July, with carbon dioxide being used to make sodium bicarbonate for dialysis machines, pharmaceutical tablets and baking soda.

Carbon capture and storage (CCS) is seen by the UK's climate change advisers as a "crucial" technology for reaching net-zero emissions, but has had a chequered history with several major projects being cancelled.

The new Tata Chemicals Europe (TCE) plant at Northwich, UK, is currently on track to capture about 36,000 tonnes of CO_2 a year. Eventually, this will rise to 40,000 tonnes, about 11 per cent of the facility's emissions, and more than 100 times the amount captured in power station pilots of CCS by energy firm Drax.

Martin Ashcroft at TCE says the £16.7 million demonstration project, helped by a £4.2 million UK government grant, shows that net zero doesn't mean outsourcing manufacturing overseas. "What we can't have is effectively decarbonisation of the UK by deindustrialisation," he says.

The CO_2 is captured from a gas-fired power plant at the facility and isn't stored, but purified and turned into liquid CO_2 to make sodium bicarbonate. "Effectively, we are making our own raw material," says Ashcroft. TCE previously bought most of its CO_2 from two of the UK's biggest fertiliser plants, one of which is closing.

Although it is a positive step, because there is no permanent storage of CO_2 at the Northwich site, it is eventually released to the atmosphere, says Stuart Haszeldine at the University of Edinburgh, UK. "This is an emissions decrease, not a permanent and durable removal of the fossil carbon released from burning the methane gas." ▮

Cybersecurity

Top websites allow bad passwords

Analysis of popular English-language sites finds many don't follow best security practices

Jeremy Hsu

THREE-QUARTERS of the world's most popular English-language websites still allow people to pick the most common passwords such as "abc123456" and "P@$$word", according to an analysis.

More than half of the 120 top-ranked websites also allow all 40 of the most common leaked and easily guessed passwords, it found. The sites include Amazon, Walmart, TikTok, Netflix and Intuit, maker of the tax-return software TurboTax that millions of people in the US use.

Amazon told *New Scientist* that it recommends users set up two-step verification and that the company may "require additional authentication challenges during sign-in" if it detects a security risk. Intuit chief architect Alex Balazs said he would investigate the findings and highlighted Intuit's use of multifactor authentication and fraud detection. The other companies mentioned above didn't respond to *New Scientist*'s request for comment.

"It's tempting to conclude that companies just don't care about users' security, but I don't think that's right… letting accounts get hacked is not at all in their interest," says Arvind Narayanan at Princeton University.

To perform the analysis of English-language websites ranked as popular by various internet services, Narayanan and his colleagues manually checked 40 passwords on each site. Using each site's password requirements, they selected 20 passwords from a random sampling of the 100,000 most frequently used passwords found in data breaches, along with the first 20 passwords guessed by a password-cracking tool.

Only 15 websites blocked all 40 of the tested passwords. These included Google, Adobe, Twitch, GitHub and Grammarly.

In 2017, the US National Institute of Standards and Technology published recommendations for websites to follow, such as including strength meters that encourage users to create stronger passwords, maintaining blocklists of leaked and easily guessed passwords and only allowing passwords that are at least eight characters.

> "Over half of the top-ranked websites allow all 40 of the most common leaked and guessed passwords"

Just 23 of the 120 most popular websites use strength meters. By comparison, 54 sites still rely on password composition policies that have poor security and usability ratings, such as forcing users to create complex passwords with a specific mix of uppercase and lowercase letters, numbers and symbols. "We definitely expected that more websites would be following best practices," says team member Kevin Lee, also at Princeton University. The team will present the findings at the Symposium on Usable Privacy and Security in Boston, Massachusetts, in August.

One reason websites may have subpar password policies is that they may prefer to spend money on other security measures because it can be difficult to measure the impact of improving password policies, says Sten Sjöberg, a Microsoft security program manager who contributed to the research while studying at Princeton University.

The security field may also have a "bit of a ratchet problem", says Michelle Mazurek at the University of Maryland. "It's not easy to roll back a protection like requiring frequent password changes… because no one wants to get blamed if something goes wrong later." ▮

Ecology

Crop-eating stink bugs could be kept at bay by wasps

BOOSTING the numbers of a tiny parasitic wasp could help control the brown marmorated stink bug (*Halyomorpha halys*), an invasive pest threatening crops including apples, cherries and corn.

In the first large-scale European field trial of a biological control against *H. halys*, mass releases of the wasp (*Anastatus bifasciatus*) in parts of northern Italy increased parasitism of the bug's eggs. The wasp, which is native to Europe, lays its eggs inside those of the pest, where its young develop by feeding on the host egg.

Alessia Iacovone at Bioplanet, an Italian biocontrol company, and her colleagues released 325,000 of the wasps over the summer of 2020. This took place at 11 orchards where the pest was known to be present, with 1000 wasps released per hectare.

The team then collected stink bug eggs, which usually occur in deposits, or masses, of 20 to 30 eggs, to establish how many had been discovered by the wasps and how effectively they had been attacked. At release sites, *A. bifasciatus* discovered 31 per cent of the stink bug egg masses and adult wasps emerged from 17 per cent of the discovered eggs, while at comparative sites where no release took place, these rates were 1.7 and 1.2 per cent, respectively (*Biological Control*, doi.org/h2xk).

EPHOTOCORP/ALAMY STOCK PHOTO

The brown marmorated stink bug is an invasive pest in Europe

In addition to these increases, the researchers found that the release of *A. bifasciatus* had no effect on parasitism by naturally occurring wasps of the same species, as well as by *Trissolcus mitsukurii*, another invasive wasp species that also targets the bug's eggs.

Iacovone says the true impact of the wasp release is likely to be even greater than simply looking at successful parasitism suggests, since the adult wasps also feed intensively on the stink bug eggs.

"*Anastatus bifasciatus* is a common egg parasitoid in parts of Europe and this report is encouraging, showing that augmentative releases of this species enhance parasitism of brown marmorated stink bug egg masses," says Glen Powell at the Royal Horticultural Society. ▮

Gary Hartley

Coronavirus

Bad candle reviews could help track covid-19 cases

Chris Stokel-Walker

NEGATIVE Amazon reviews of scented candles may indicate the number of covid-19 cases in the community and could even predict infection spikes.

Viral Twitter posts have suggested that Amazon reviews for highly scented products could highlight the extent in the population of anosmia, or a loss of smell, a key covid-19 symptom. To learn more, Nick Beauchamp at Northeastern University, Massachusetts, and his colleagues analysed 9837 Amazon reviews of four best-selling scented candles produced by the brand Yankee Candle. All were posted between September 2018 and December 2021.

They noted the number of reviews that said the candles had no smell and compared them with reported covid-19 cases in the US.

The research "started out as a joke", says Beauchamp, however, the team found a link between covid-19 cases and negative candle reviews. For every 100,000 new covid-19 cases a week in the US over the study period, the number of Yankee Candle reviews saying the product had no smell went up by 0.25 percentage points. A statistical analysis revealed this link wasn't a chance finding.

The connection also persisted despite the study covering the beginning of the omicron wave in the US, spanning December 2021 to February 2022. Omicron causes anosmia less commonly compared with previous coronavirus variants. The link also still stood after the researchers accounted for other seasonal illnesses that can affect smell. The team presented the work at the International AAAI Conference on Web and Social Media in June.

Monitoring scented candle reviews could track covid-19 cases as regular testing winds down worldwide, says Beauchamp.

Space

UK plans launch of spacecraft to grab two dead satellites

Jonathan O'Callaghan

THE UK is committing £5 million to fund a mission to remove space junk. The project will aim to bring two defunct satellites back through Earth's atmosphere later this decade – a first-of-its-kind feat.

Speaking on 23 June at the Secure World Foundation's Summit for Space Sustainability in London, UK science minister George Freeman outlined a commitment to keeping Earth's orbit clean and tidy as part of the UK's Plan for Space Sustainability. This includes drawing up regulatory norms for the operation of satellites and lowering insurance costs for sustainable missions.

"We're at the cusp of a massive explosion of satellites," said Freeman. "We want to make sure we lead in the science of sustainability."

The UK's Active Debris Removal mission, first announced last year, will see a spacecraft launched into orbit in 2026. Once there, it will journey to two dead UK satellites orbiting our planet and pull them back into the atmosphere so they burn up, proving that a single spacecraft can remove more than one piece of debris.

"Removing multiple pieces of debris with a single vehicle is the right way to go," says Hugh Lewis at the University of Southampton, UK. More than 30,000 pieces of debris in Earth's orbit are tracked today, including some 2500 dead satellites.

30,000

More than this many bits of space junk are being tracked

Current debris removal plans, such as an upcoming mission by Swiss company ClearSpace in 2025, funded by the European Space Agency, are focused on removing just one piece of debris. The UK's mission will be the first to target multiple pieces, with the removal spacecraft designed to be left in Earth orbit, possibly for future refuelling to tackle more junk.

Three companies are vying for the contract: ClearSpace, Japanese-UK company Astroscale and UK-based Surrey Satellite Technology (SSTL). Two will be selected to share the £5 million fund in July, then a single firm will be picked by the end of 2023 with a contract worth up to £60 million.

"Space debris is a huge problem," said Freeman. "The aim is to make the UK a world leader in satellite retrieval systems."

Each company has a different proposed method to carry out the mission. Astroscale would use a robotic arm to grab each dead satellite, Clearspace plans to use four arms to "hug" the objects and pull them down, while SSTL is investigating the possibility of using a giant net to grab one, pulling the other down with an arm.

The two defunct UK satellites have yet to be chosen from more than a dozen targets.

While there are no major legal hurdles to a country targeting its own satellites, there are mission issues that will need to be cleared with the Civil Aviation Authority in the UK, says Joanne Wheeler, a lawyer at London-based firm Alden Legal. "What happens if you go up there and attach to the wrong object?" she asks, saying it could be a national security issue.

The hope is that the scheme will spur more commercial debris-removal missions. "We're trying to speed up the development of these technologies," says Jacob Geer at the UK Space Agency. "We're sending one satellite to remove two objects. There's a net loss in the amount of objects in space. It's an important step for everyone, not just the UK."

CLEARSPACE

Artist's impression of ClearSpace's satellite-grabbing craft

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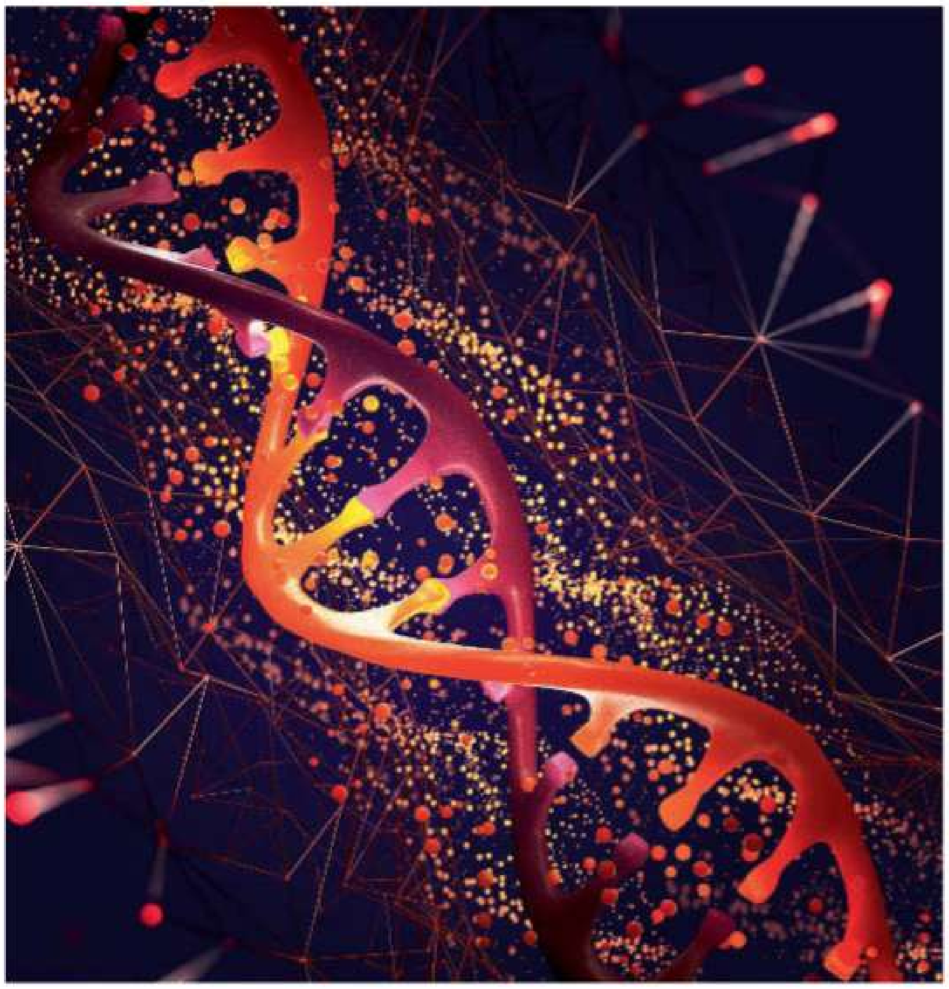
Gene editing

What's next for the CRISPR babies?

Three children in China who underwent CRISPR gene editing as embryos may need more healthcare over their lifetimes, but shouldn't become a science project, finds **Nicolas Gutierrez C.**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CRISPR technology changes DNA by cutting specific sequences

MORE than a billion people live in China, but researchers in the country have proposed the creation of a healthcare institute to look after just three: Amy and twins Lulu and Nana. These three children are the first genetically engineered humans in history.

Known publicly only by these pseudonyms, as embryos their genomes were edited using CRISPR technology by scientist He Jiankui in an effort to prevent them contracting HIV from their fathers. After announcing the experiment to the world in 2018, He was denounced as highly unethical. He was imprisoned in China in 2019 and was released in April this year.

> **"CRISPR is often referred to as molecular scissors, but this implies more precision than it has"**

The children are now toddlers, and as they grow up the scientific community faces a complex dilemma: how to care for their well-being and any fallout from He's experiment, while also respecting their private lives.

"In my opinion, the best way to provide them with special protection is to establish a centre to perform surveillance, regular or irregular examination, and treat and care for them when they fall ill, which may be caused by genetic abnormalities," says Qiu Renzong, a bioethicist at the Institute of Philosophy at the Chinese Academy of Social Sciences. Along with his colleagues, Qiu has presented a proposal for this facility to other scientists and several Chinese government ministries.

CRISPR is a molecular technology that can find a specific region in the genome and cut through it. He used it to delete a portion of the gene *CCR5* in the three children's genomes, an alteration known to be protective against HIV. But this technology isn't infallible.

Anomalies in the children's genomes are very likely, says Kiran Musunuru, a cardiologist and geneticist at the University of Pennsylvania and author of *The CRISPR Generation: The story of the world's first gene-edited babies*. "CRISPR is often referred to as molecular scissors, but this implies a level of precision that it does not have," he says. "Rather than cutting a precise point in a page like scissors would do, it is more like tearing through the page."

After a cell's DNA has been cut by CRISPR, its molecular infrastructure puts the two ends back together. But this is often imperfect, either adding or removing some DNA letters.

3

Age of the three children born following CRISPR gene editing

"Another, more serious, issue is that the edit in the target gene could also affect the genes around it. In some cases, whole pieces of chromosomes could be deleted, which could lead to all sorts of developmental issues," says Musunuru, such as problems with the heart.

These "off-target" edits are a known issue with CRISPR. Such uncontrolled cuts could have happened anywhere in the children's genomes. According to Musunuru, who is one of the few researchers in the world to have had access to He's unpublished scientific paper after being given a copy by the Associated Press, there is very strong evidence suggesting this occurred.

Editing errors

"From the data in He's manuscript, it was clear that there were off-target edits. He described some of these edits found in placenta tissue and umbilical cord tissue, but he dismissed them because the ones they saw were not in genes. But this showed that these edits were happening," says Musunuru. "And their location cannot be predicted, so this may happen in a gene related to cancer, increasing the risk of developing cancer early in life. This is the biggest clinical risk."

Another alarming finding is that these edits were different from one cell to another, known as mosaicism, making their consequences even more unpredictable.

"CRISPR was injected when the embryo was only a single cell, but it stays in the cell for hours and even days while the embryo starts to divide within hours. So CRISPR could potentially go into all of these cells and do different edits in all of them, creating a patchwork

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of genetic edits," says Musunuru. "When I saw the data from the embryos, it was immediately clear that there was mosaicism in the embryos that gave rise to Lulu and Nana: they had different edits in different cells. This mosaicism, where cells in the same tissue could behave differently because of genetic differences, can cause health problems like heart disease."

All of this suggests there is a strong argument for closer medical monitoring for the three children than for other children. But Qiu sees another reason for life-long monitoring: the potential for deepening our understanding of the heritability of human genome editing.

Although this technology is banned around the world, Qiu argues we need to study it anyway, in order to be prepared for any further illegal experiments. His proposed research centre would not only treat all such children, but also improve gene-editing technology to make it safer for future, legal use.

"Properly treating genome-edited persons is an ethical imperative and a prerequisite for smoothly developing heritable genome editing," he says. He points to conditions such as thalassemia, an inherited blood condition that causes anaemia and affects 47 million people in China. Thalassemia can be treated with regular blood transfusions, but there is currently no cure – something gene editing could change.

Bioethicist Françoise Baylis at Dalhousie University in Canada, author of *Altered Inheritance: CRISPR and the ethics of human genome editing*, says the twin goals of Qiu's institute would be at odds. "There is a critical ethical difference in monitoring to promote the patient's best interests and monitoring for knowledge production," she says.

Baylis says any efforts focused on the best interests of the children would need to protect their privacy and confidentiality, not prioritise science. "Long-term follow-up is essential, but this should be done by a team of clinician-scientists in a healthcare facility," she says. "It is important to ensure that the children have as normal a life experience as possible. Already they will be subject to many more medical visits than other children; they ought not to bear the additional stigma of having to report to a research centre."

S.C. LEUNG/SOPA IMAGES/LIGHTROCKET VIA GETTY IMAGES

He Jiankui announced his CRISPR experiment in 2018

"As a physician, I would like to keep a much closer eye on them than with any other child and have them come for check-ups, imaging tests and blood tests much more frequently, to see if there is anything strange going on in their bodies," says Musunuru. "But this care could be given in the community. A full research centre for them feels like really treating them as experimental subjects, because such a centre would imply invasive testing and taking a lot of tissue samples for examination and DNA analysis. That level of scrutiny feels a little dehumanising."

Qiu argues that normal healthcare facilities aren't equipped to deal with the special health risks of these children. "They could live a normal life and go to a normal hospital when they get a cold or other minor disease. However, if there is any clinical symptoms or signs related to genetic abnormalities, the general hospital will not be able to treat them nor provide appropriate genetic surveillance and examination. The onset of clinical symptoms of a gene abnormality may take time, that is why the surveillance and examination of their genome are very important."

"It is important to ensure that the children have as normal a life experience as possible"

Musunuru takes a different view. "If the genetic issues are there, it is hard to stop them from happening; we could only act once a tumour is starting to form to give the appropriate treatment," he says. "Scientifically, it would be of interest, but it would not help the health of these kids directly."

Ultimately, the final decision belongs to the Chinese government. "The situation is completely unprecedented and we cannot predict what the government will do," says Musunuru. "It is my hope that they choose a reasonable middle course where the girls are taken care of but not in a way that is too burdensome to them." ∎

The next generation

The type of healthcare chosen for the first three gene-edited children could have consequences throughout their lives, including for their most intimate decisions, such as having a child. While gene editing may have generated harmful mutations in their genomes, these would probably only be present in some cells or tissues (see main story).

Such mutations may not cause any medical issues for the girls, but they could represent a risk for future generations. If one of these harmful mutations is in an egg cell, and this ends up becoming a child, the child would have this mutation in every cell of their body, which would cause medical issues.

These second-generation CRISPR children would then have a higher probability of passing harmful mutations on to their own children.

One solution would be for the children to only have children through in vitro fertilisation (IVF), to allow exhaustive screening of their eggs and embryos to be sure that a worrisome mutation can't be inherited.

A more drastic approach would be sterilisation, preventing the three children from passing on their genes. This suggestion is likely to be considered highly unethical by most people, but the Chinese government has allegedly forced women from the Uighur ethnic minority group to be sterilised – an accusation the government denies.

Biology

Giant bacteria that are visible to the naked eye upend microbiology

Carissa Wong

PIERRE YVES PASCAL/LAWRENCE BERKELEY NATIONAL LABOR

***Part of a Thiomargarita magnifica* (inset), which lives in mangroves**

THE world's largest known bacterium has been found in the tropical mangroves of Guadeloupe in the Caribbean. It is about a centimetre long, with a structural complexity not seen before in such single-celled life forms.

Most bacteria are around 2 micrometres in length, or 0.0002 centimetres. Their size is limited by the fact that the energy-carrying molecules they use to power themselves, known as ATP, are produced using enzymes embedded in the cell membrane. This means bacteria need to have a suitable surface-area-to-volume ratio to function.

That being said, we already knew that bacteria could grow larger, with one species – *Thiomargarita nelsonii* – reaching up to 750 micrometres long. This is, however, still within expected theoretical size limits imposed on bacteria.

The new bacterium – named *Thiomargarita magnifica* – has a volume about 50 times that of *T. nelsonii*, breaking those limits.

> "Each *Thiomargarita magnifica* cell is about a centimetre long and structurally complex"

Olivier Gros at the University of the French Antilles, Guadeloupe, said at a press briefing that he first encountered the supersized species on an expedition in 2009. "I found long, white filaments attached to sunken leaves of a mangrove tree. At first, I thought they were some kind of eukaryote [animal, plant or fungus] due to their size," he said.

By imaging *T. magnifica* cells, Gros and his colleagues revealed that they have an extended network of membranes – studded with ATP-producing enzymes – packed within their cell volume. This allows them to meet their energy needs despite their size.

The team speculates that the long and thin bacteria may have evolved to access sulphur in the sediments at the bottom of the mangroves as well as oxygen in the seawater above, which they use to generate energy.

By labelling the membranes of *T. magnifica* cells with a dye and imaging them, the researchers also discovered that the cells store their DNA and their protein-making ribosomes inside sacs made from cell membrane. This is a feature normally only seen in more complex cells such as those found in animals (*Science*, doi.org/h2wx).

Despite its unusual features, *T. magnifica* has many genetic similarities with members of the *Thiomargarita* group of bacteria and fits nicely within the current tree of life. But its discovery will still have big implications, says Gerard Muijzer at the University of Amsterdam in the Netherlands.

"The impact of the study is enormous. All microbiology textbooks mention that bacteria are small and simple. However, the results described in this paper will completely change our view on these aspects," he says. ▮

Astrophysics

Light delayed by seven years by galaxy cluster

LIGHT from a quasar has been delayed for seven years as its path to us was diverted by the gravity from a cluster of galaxies. It is the longest recorded delay of its kind.

When an object is massive enough, it can act as a gravitational lens that bends light around it. For those watching from Earth, this can produce multiple images of things behind the big object because light for each image takes a different path and arrives at different times.

ESA/NASA/KEREN SHARON/ERAN OFEK

The four white dots around the centre of this image are light coming from the same quasar

Jose Muñoz at the University of Valencia in Spain and his colleagues have now measured the light from four images of a quasar – a supermassive black hole with a bright disc of material circling it – that had been bent by a cluster of galaxies called SDSS J1004+4112 over more than 14 years, using the Fred Lawrence Whipple Observatory in Arizona.

Three of the images, A, B and C, had been measured by previous groups, but the fourth, D, hadn't. By taking repeated light readings of all four images and performing statistical analyses, Muñoz's team confirmed previous measurements and determined a delay time for D: about 2458 days, or nearly seven years (arxiv.org/abs/2206.08597).

"For a system with such a long delay, you get many more data points and can measure the delay more accurately," says Stephen Warren at Imperial College London. The accuracy of the delay is unlike anything we have for other lenses from cluster galaxies, he adds.

By calculating the delay between these different images, astronomers can measure the Hubble constant, a number that represents how fast the expansion of the universe is accelerating.

All but one of the predictions that had been made for the delay for image D were incorrect. The errors aren't surprising, says Mathilde Jauzac at Durham University, UK. "The fact that at least one of the models managed to encompass the direct measurement presented in this paper is already quite a step." ▮

Alex Wilkins

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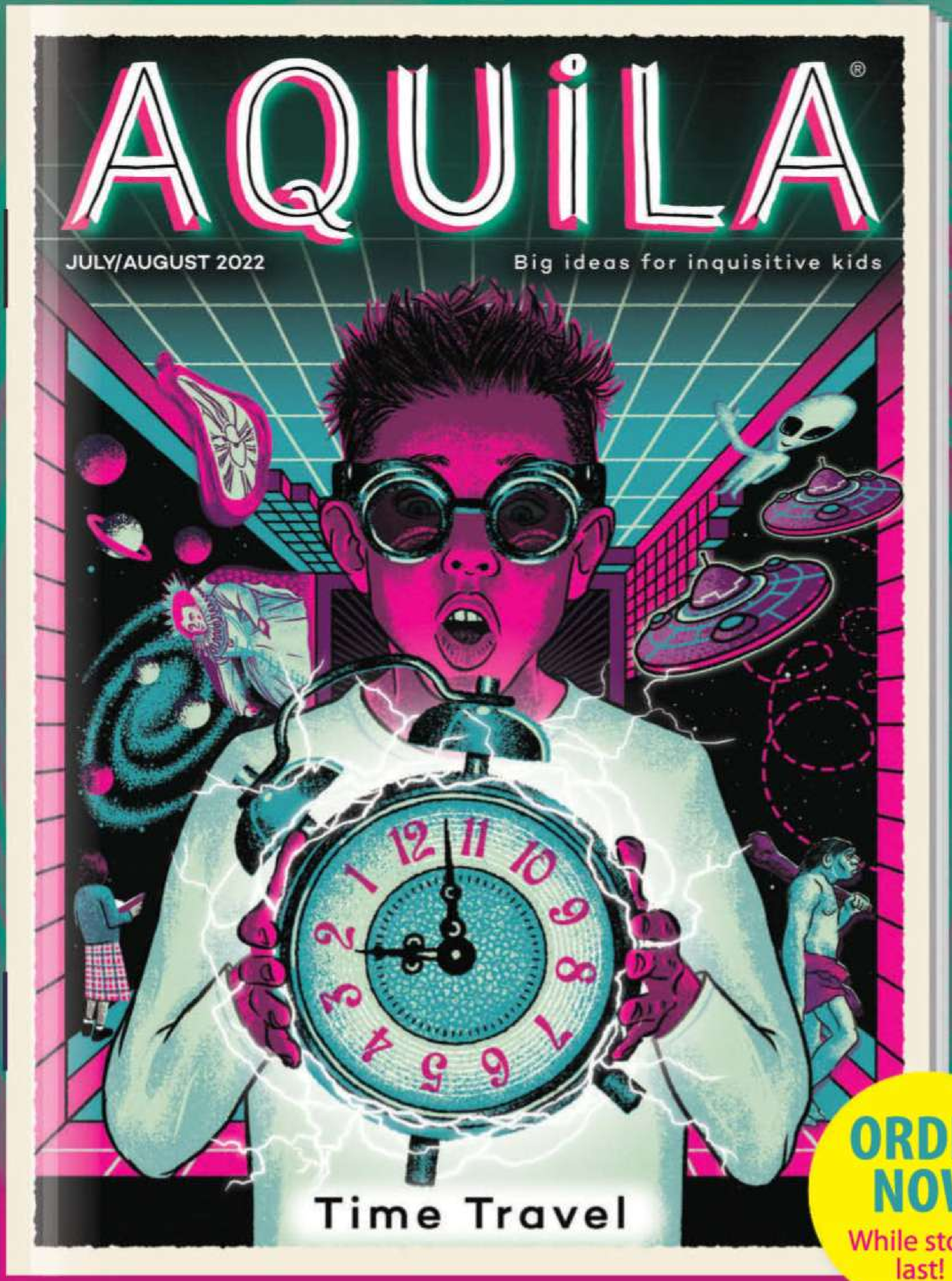

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Zoology

Tiny hummingbirds top the chart for plumage colours

MARTIN MECNAROWSKI/SHUTTERSTOCK

HUMMINGBIRDS may be the most colourful birds in the animal kingdom – at least, they are from the perspective of the birds themselves. An analysis of 114 species of the small, nectar-supping birds suggests they can collectively produce more than one-third of the colours their eyes can theoretically detect.

Birds in general are renowned for their colours, but exactly how colourful they are is difficult to quantify. One way to measure colourfulness is to consider the theoretical total number of colours birds can see, and then estimate how many of these colours are produced by the birds' feathers.

A 2011 study that took this approach to look at a wide variety of birds found that they typically produce only about 30 per cent of the colours they can see.

Gabriela Venable at Duke University in North Carolina and her team have performed similar work focusing on 114 different species of hummingbird.

From their analysis, the team estimates that hummingbirds can produce 34 per cent of the colours they can see (*Communications Biology*, doi.org/h2xp).

Most birds can see more colours than people because they have extra receptors in their eyes that let them see UV light.

The team also determined that hummingbirds may be so colourful because of the way that certain cellular structures in their feathers are organised. These pigment-producing organelles are layered in such a way that they interfere with light and produce vibrant shades.

Jason Arunn Murugesu

Physics

New sign of strange neutron material

THERE is fresh evidence that an exotic and elusive type of matter consisting of four neutrons that briefly bind together exists. Signs of the "tetraneutron" first cropped up 20 years ago, but a new study has found more convincing proof.

While all matter contains neutrons, only neutron stars contain matter made entirely of the particles, bound together by nuclear forces. However, it isn't known exactly what structure this neutron-only matter has.

In 2002, researchers realised that tetraneutrons may form after collisions between beryllium and carbon atoms. However, the experiments had large margins of error and left room for other possible explanations.

Roman Gernhäuser at the Technical University of Munich in Germany and his colleagues used a different particle collision to try to find more definitive evidence.

They created helium atoms that have four more neutrons than usual, then collided them with protons. The idea is only four neutrons remain and they can then combine into a tetraneutron.

The researchers measured the energy and momentum of all the particles pre and post-collision. From past experiments and theoretical calculations, they knew how much energy should be "missing" after the collision if a tetraneutron forms.

Gernhäuser says this energy was measured with unmatched precision because the experiment was designed to suppress every reaction that could have interfered with or been mistaken for the creation of a tetraneutron. From this, they say that tetraneutrons formed, but for a mere 10^{-22} seconds (*Nature*, doi.org/h2xh).

"This is a real tour de force," says Martin Freer at the University of Birmingham in the UK.

Karmela Padavic-Callaghan

Health

Cancer cells spread more when sleeping

BREAST cancer cells spread to other parts of the body mostly at night while people are sleeping.

This doesn't mean that people with cancer should try to avoid sleeping – previous work has suggested that disrupted sleep could worsen a breast cancer prognosis. But it does indicate that considering the best time of day to give cancer therapies could make them more effective, says Nicola Aceto at ETH Zurich in Switzerland.

GORODENKOFF/SHUTTERSTOCK

Aceto and his team had been studying metastatic breast cancer when they saw an unexpected trend. The participants' circulating tumour cells (CTCs), cells that spread out from invasive tumours, were proliferating mostly at night.

They decided to investigate further in 30 women with breast cancer, including nine with metastatic disease, who weren't undergoing treatment. The team collected blood at 10am and 4am.

Analysis revealed that 78 per cent of all the CTCs were found in the night-time samples, when the women had been sleeping.

The team then ran similar tests on mice with four types of breast cancer. Depending on the cancer type, between 87 and 99 per cent of the CTCs came from samples taken during the animals' sleep periods. What's more, these CTCs clustered more, meaning they were more likely to form a tumour (*Nature*, doi.org/h2xf).

Christa Lesté-Lasserre

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Really brief

RUDMER ZWERVER/SHUTTERSTOCK

Tortoises challenge theories of ageing

Some tortoises and turtles in captivity have a lower rate of ageing as they grow older – which means that, at a population level, the risk of death decreases. The results apply to species like the Greek tortoise (*Testudo graeca*, pictured) and suggest ideas on ageing need a rethink (*Science*, doi.org/h2t5).

Megalodon ate other killer fish

The 15-metre-long, extinct megalodon shark (*Otodus megalodon*) may have been higher up the food chain than any living marine predator, meaning it hunted other predators. The finding comes from an analysis of nitrogen isotopes in the shark's fossilised teeth (*Science Advances*, doi.org/gqc8kv).

Smell is a factor in our friend choices

People with similar body odours are more likely to become instant friends, experiments suggest. Researchers placed strangers in pairs and found those who reported that they "clicked" were also judged by an "electronic nose" to have similar body odour (*Science Advances*, doi.org/gqdntx).

Diet

Protein in faux meat less easily absorbed

DIETARY protein from plant-based meat alternatives may not pass across the gut wall as well as protein from chicken.

To investigate, Da Chen, now at the University of Idaho, and Osvaldo Campanella at The Ohio State University and their team grew human gut cells on scaffolds that divided several dishes into two chambers. They then used enzymes from the stomach and small intestine to digest a plant-based meat alternative and a cooked chicken breast, before adding each digested product to one chamber in each dish.

Next, the team measured the amount of protein fragments – or peptides – that passed through the layer of gut cells to reach the opposite chamber in each dish, representing the absorption of protein through the gut.

Within 4 hours of being added to the dish, about 2 per cent less protein from the plant-based meat alternative had moved through the gut cells, compared with protein from the chicken breast. Although a small difference, statistical analysis suggests this result wasn't a chance finding (*Journal of Agricultural and Food Chemistry*, doi.org/h2xg).

Eating meat alternatives may therefore result in less protein being absorbed through our gut wall into our bloodstream. The researchers didn't assess whether this reduced absorption leads to protein deficiency. They say the effect may be because protein fragments from chicken breast are smaller and more soluble in water than meat-alternative peptides. **Carissa Wong**

Archaeology

ALASTAIR KEY

Stone axes turn out to be the oldest found in the UK

A CACHE of prehistoric tools used by ancient humans living in what is now the UK has been confirmed to be at least 560,000 years old. The artefacts are the oldest of their kind found in the country.

Archaeologists first dug up ancient hand axes at a site in Fordwich, Canterbury, in the 1920s. But their age was unclear. Alastair Key at the University of Cambridge and his colleagues have now used a modern technique to determine the ages of several of the tools.

The team used a method called infrared radio-fluorescence dating to establish how old the tools were. This involves dating sand in which the tools were buried – only possible after new digs helped establish which layer of sand the axes were in.

The team estimates that the tools are about 560,000 to 620,000 years old (*Royal Society Open Science*, doi.org/gqc7c2). This makes the axes among the earliest found in Europe. But they are still fairly young compared with axes found in Africa, says David Bridgland at Durham University in the UK, who worked on the study.

***Homo heidelbergensis* could be the human species that produced the axes, says Chris Stringer at the Natural History Museum in the UK.** JAM

Animal behaviour

Chimps can find their way in a digital world

CHIMPANZEES in a zoo have been trained to use a touchscreen to navigate a virtual environment and seek out objects. Studies like this could help us learn more about how our close relatives find their way around in the jungle.

Over several weeks, Matthias Allritz at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and his team trained six zoo chimpanzees to use a touchscreen and play a video game in which they had to navigate to a tree to find a piece of fruit. In one experiment, the chimpanzees tried multiple times to find the same tree from the same starting point. In another, they started from a different position in the virtual environment. The team wanted to see if the animals could still navigate to the tree in order to collect the virtual fruit.

With practice, all six chimps could complete both tasks. But only three improved the efficiency of their routes with practice in the first task (*Science Advances*, doi.org/h3bp).

Testing chimpanzees in virtual environments could give us a better idea about why they prefer certain routes in the wild, where it is often hard to track them. **JAM**

Unlock your body's potential

By measuring body chemistry and mining the data, InsideTracker is pioneering personalised, evidence-based insights into health and fitness – and how to improve it

Gil Blander is a huge fan of what's flowing through your veins. "Blood is the equivalent of liquid gold," says the former research biologist, now founder and Chief Scientific Officer of InsideTracker, an innovative wellness startup.

Blander's appreciation of blood arose from the realisation that, for more than 100 years, peer-reviewed scientific publications have been detailing the biological information that blood carries. There is a wealth of largely untapped potential in that literature, Blander points out.

Now, though, that potential is being tapped. InsideTracker has performed a broad analysis of scientific papers about blood's "biomarkers", and combined it with genetic information from DNA samples, and personal health data from fitness trackers. So the company's software can chart an individual's potential, their performance and, through regular blood sampling, the effect of scientifically-sourced tweaks. "Blood changes with time and with intervention so it gives you feedback," Blander says.

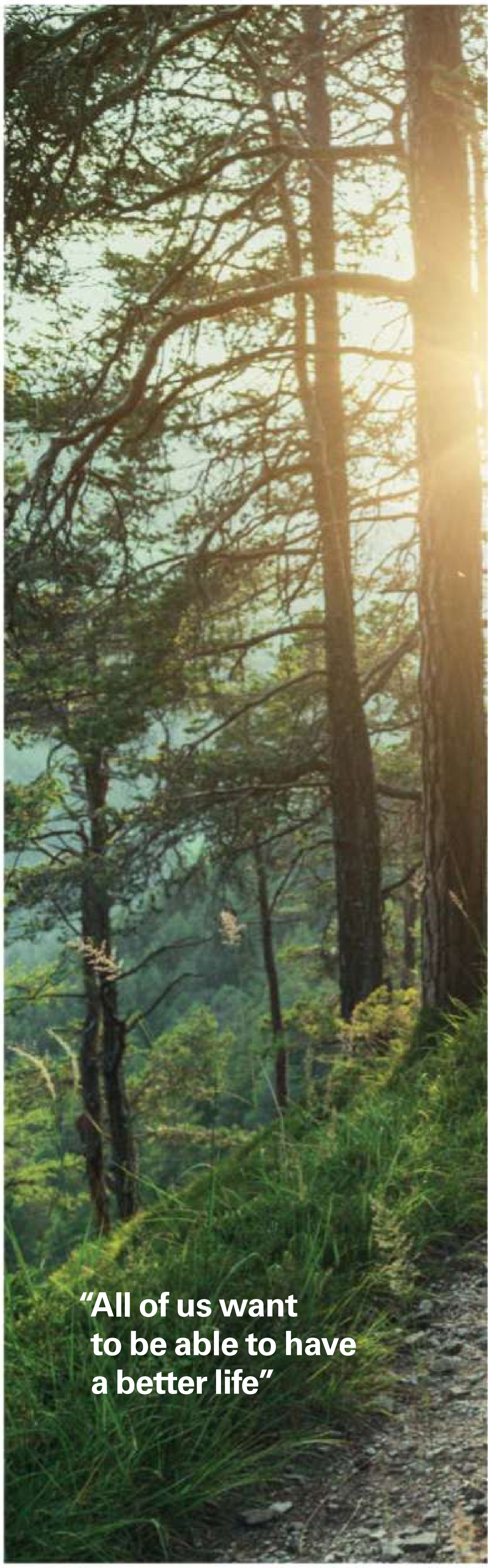
This feedback signifies a giant leap forward for personalised health. Gideon Akande is a former collegiate athlete and three times Chicago Golden Gloves boxing champion who is now working as a fitness professional (see *Giving Power to the People*). He says being an InsideTracker customer has made a significant difference to him. "I love that I can learn about my internal status and take away actionable items to become a better version of me," he says.

Wanting to improve quality of life is all very well, but that requires having a measure of success. This is where the blood comes in. The liquid gold in our veins contains thousands of biomarkers that highlight good health. Blander set out to identify those that respond to intervention, whether through food, supplements, exercise or lifestyle choices. He further narrowed them down to those biomarkers that are relevant to most people. "We don't want to look at something that's 1 in 10 million, because then you're not giving a useful service to the majority of the population," Blander says.

Today, InsideTracker follows around 45 blood biomarkers and is adding more as the science shows their value. "We can tell you what each thing means, why it's important, and give you recommendations to optimise your health. That's something that was impossible 10 years ago."

The tumbling cost of genetic analysis led the company to add DNA into the mix. "It's much cheaper now, and more accessible," Blander says. The value of DNA analysis is that it shows a person's potential, and any susceptibilities, such as a tendency to abnormally high cholesterol or difficulty managing blood glucose levels. "If you combine DNA analysis with blood analysis we know your current level of glucose and whether you are high risk or low risk for having high glucose," Blander explains. "Based on that, we can inform you — and give you a specific recommendation."

The recent boom in fitness trackers has added another layer to InsideTracker's analysis. "We have started using data from from FitBit, Garmin and Apple Watch," Blander says. "We can log your REM sleep, your deep sleep, resting heart rate, heart rate variability, and other markers of health. It's



"All of us want to be able to have a better life"

the kind of information that used to only be available if you went to a sophisticated lab."

This daily flood of data, analysed alongside regular blood tests and matched against a user's DNA profile, allows InsideTracker's scientists — including exercise physiologists, biologists, nutritionists and data scientists — to give frequent personal recommendations supported by machine learning algorithms that comb the scientific literature.

The algorithms might compile all the data about coffee, for example: hundreds of papers that show coffee combined with running is good for reducing high LDL cholesterol, or how it interacts with heart rate for people of a certain age, or ethnicity, or genetic predisposition. "Instead of saying coffee is good for everyone, we can say that if you are X, coffee is good for you, in terms of helping with this specific outcome," Blander says.

Other recommendations might be concerned with what to eat or drink after a workout, what supplements to take to support your level of activity, or simply how to adjust sleep schedules for best recovery. Each recommendation comes via an app with pointers to supporting peer-reviewed scientific publications. "I don't like a black box: I want it to be completely open, for people to read and understand," Blander says.

A peer-reviewed study published in the Nature journal Scientific Reports in 2018 (DOI:10.1038/s41598-018-33008-7) showed that InsideTracker's approach makes a positive difference. The company looked at 1,000 users, comparing their blood biomarkers from baseline to follow-up. Between them they used 525 different, highly personalised interventions. Whether they started with high LDL cholesterol, high glucose, inflammation markers or something else entirely, their particular problem biomarkers were moving towards the individual's precisely defined "optimal" range after seven months. "It shows that with this population, when you give them an intervention, blood biomarkers will improve significantly," Blander says.

Blander is enjoying fulfilling his life's goal. "All of us want to be able to have a better life, and to be climbing mountains when we are 80 or 90, to go for a run, to enjoy our grandchildren," he says. "That's what I've been aiming towards, and it's so exciting to have this finally become possible."

Try InsideTracker with a 20 per cent discount at: insidetracker.com/newscientist

GIVING POWER TO THE PEOPLE

California-based actor and nutritionist Melanie Avalon had been tracking her bloodwork for years before discovering InsideTracker. "I wanted to take charge of my health, but found it quite difficult to keep on top of everything, and to make sense of all the data." She has had trouble with anaemia in the past, sometimes needing to be hospitalised, but the information from InsideTracker has helped her resolve the issues. "InsideTracker's full iron panel revealed a state of anemia which my conventional doctor didn't spot," she says.

With data and advice from Inside Tracker, Avalon has also tracked and stabilised her Vitamin D and blood glucose. "I mostly use the combination of genetic information and blood analysis," she says. "I find it so encouraging, especially when I see that I'm doing 'better' than my genes might otherwise indicate. By seeing your genetic data in combination with your actual blood results, you can see how your epigenetics and lifestyle are interacting with your genes. This is so empowering!"

Fitness professional Gideon Akande is similarly impressed. "It's so rewarding to know that InsideTracker's recommendations will work for me, and the biomarker data is always there to prove it," he says.

Akande plans to keep optimising his health into old age for a whole swathe of reasons: to enjoy sports and athletics into old age; forge memories with his family; gain freedom from health concerns, and to travel and enjoy retirement age when the time comes. "Basically, I want to live fully, and InsideTracker gives me all that I need to do just that."

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Comment

A lighter touch

New guidelines recommending abstinence from alcohol in pregnancy may do more harm than good, says **Jules Montague**

SIMONE ROTELLA

"THEY know that they have a tummy mummy. And she drank alcohol when they were in her tummy." That is how Alison, who lives outside Belfast, UK, explains things to her adopted sons Sean (13) and James (12). "I tell them alcohol made their brains different, so they learn different," she told me. "But it also makes them very special."

Fetal alcohol syndrome (FAS) has profoundly affected the brothers, causing intellectual delays and impaired mental processing. Alison's stance is unambiguous. "If you drink whilst pregnant, you're playing Russian roulette with that baby's life," she says.

New guidance from the World Health Organization (WHO) echoes this, recommending "appropriate attention… be given to prevention of drinking among pregnant women". But this may harm mothers and babies, even as it seeks to save them.

FAS was first described in 1973 in three babies born to women with "chronic" alcoholism. Later reports highlighted the typical physical features of FAS: a thin upper lip, narrowed eye openings, restricted growth and smaller head.

Successive directives advised moderating alcohol intake during pregnancy, followed by abstinence warnings backed by what is now the US Centers for Disease Control and Prevention; the former chief medical officer for England, Sally Davies; and the UK's Royal College of Obstetricians and Gynaecologists. The legacy of FAS on Sean and James suggests alcohol abstinence in pregnancy represents a small sacrifice. The truth is more complex.

A 2017 analysis of 26 studies concluded it isn't possible to say light drinking (4 units spread over the week) harms a developing fetus. Public health organisations draw on the precautionary principle – broadly, "better safe than sorry". But abstinence directives, issued in the face of equivocal evidence, have wide ramifications.

Firstly, expectant mothers are subjected to value-laden campaigns, such as an Italian one showing a fetus in a glass. "*Mama Beve, Bimbo Beve*", it reads: "Mother Drinks, Baby Drinks". A desire to distinguish "bad" mothers from "good" ones endures.

The WHO's guidance could harm the babies it aims to protect. Several US states support mandatory reporting of certain behaviours during pregnancy to law enforcement or child welfare agencies. A 2016 study found that once reported, women have frequently faced involuntary treatment and jail time for their alcohol consumption, and have had their children removed – irrespective of whether they have come to harm. In such states, more babies are born prematurely and with low birthweight. This could be because those who think they are drinking more than they should during pregnancy may be reticent to seek broader prenatal care or alcohol counselling.

Discriminatory judgements ensue. Studies have found that pregnant Black women are more likely than white women to be screened for alcohol use, and more likely to face legal action, even after treatment for alcohol dependence. Tragically, they are also more likely to lose custody of their child, and less likely to be reunited with them. Similar findings exist for pregnant women in lower socio-economic groups, whether they are a member of an ethnic minority group or not.

Abstinence directives rooted in the precautionary principle imply it isn't possible to process a message beyond "this is for your baby's good". Shouldn't we instead state that binge and heavy drinking may irrevocably harm a fetus, but that science doesn't provide the same indisputable link for light drinking? Public health groups should elevate the subtlety and sensitivity of their messaging. We must hold Sean and James in our minds, but these conversations are necessary, to protect mothers as well as their babies. ▮

Jules Montague is a neurologist and author of *The Imaginary Patient: How diagnosis gets us wrong*

My botanical life

To market, to market

Plant-ripened fruit and veg are packed with more nutrients than produce harvested early for bulk sales. Let's celebrate farmers' markets, says **Beronda L. Montgomery**

Beronda L. Montgomery is a writer, researcher and biochemist who studies how plants detect and respond to their local light environment. She is the author of *Lessons from Plants*. You can follow her on Twitter @BerondaM

Beronda's week

What I'm reading

On Spiritual Strivings: Transforming an African American woman's academic life *by Cynthia B. Dillard*

What I'm watching

The docuseries Equal *on HBO Max*

What I'm working on

Right now, it seems I am occupied with writing reference letters for the upcoming academic job market season!

This column appears monthly. Up next week: Chanda Prescod-Weinstein

NEARLY every trip back to the city after visiting my maternal grandparents in rural Arkansas included a stop at a roadside farmstand where we would buy seasonal vegetables like string beans, peas or deep-green, leafy collard greens. Preparing the vegetables for cooking was one of my first lessons in plant anatomy, as my mom and grandma taught me to meticulously remove the tough petiole from the green leaves.

We bought the juiciest fruits: huge strawberries and fist-sized peaches and plums. My mom was sure these fruits and vegetables, fresh from the field and ripened on the plant, had more vitamins and flavour than those at our city store. Some of my favourites were summer vine-ripened tomatoes, so rich in flavour that I ate them whole, like apples.

I learned that farmers' markets were a place to celebrate plants of the season and the individuals who cultivated them. I gleaned so much knowledge about which plants grew when, and how to identify plant-ripened fruits. I have reflected frequently on the wealth and breadth of the growers' knowledge as I have studied plants in my own research.

But do local growers' wares really taste better? It is clear that fruits and vegetables can lose nutrients after being picked and stored. Cut from the mother plant prematurely, fruits and vegetables that have been harvested early have a shorter time in which to accumulate and store sugars and nutrients than those that are left to fully ripen on the plant. When harvested early like this, they will also use more of their stockpiled nutrients to support themselves during the longer storage time.

It can be common for commercial fruits to be harvested unripened and then treated with ethylene gas to induce ripening after storage. By contrast, plants naturally produce ethylene during the course of maturation to ripen their fruit. Since ethylene initiates ripening while these on-the-plant fruits are still accumulating nutrients and sugars, their flavour and nutrient profiles differ from those ripened in storage.

> "Local farmers often grow more diverse plants than larger farms, which grow in bulk for large-scale sales"

My mom was right: due to having increased time to access nutrients from the mother plant and reduced time between harvest and consumption, plant-ripened fruits and vegetables can indeed have higher nutrient contents than those harvested, transported and ripened separately.

Over the years, my son and I have enjoyed visiting local markets in search of our seasonal favourites – richly flavoured heirloom tomatoes that can differ from grower to grower, sunchokes (Jerusalem artichokes) that we first encountered at a market and local Michigan cherries that taste like no others. I remember buying Brussels sprouts intact on the stalk and receiving instructions from the grower on roasting them whole. While I thought the stalk was inedible, the grower informed me that it was nutrient-rich, and could be served up once softened.

Farmers' markets have grown in popularity with people invested in the local food movement, which is focused on increasing consumer knowledge about plants and the sustainability of agricultural food production, as well as supporting local growers. Recently, local food movements have also been linked to positive environmental change through reducing the climate-associated costs of long-distance food distribution.

The pandemic and disruptions to the food supply chain have bolstered interest in the local food movement and farmers' markets. These spaces were critical both for consumers seeking alternatives to disrupted supply chains and farmers needing outlets to sell produce, including those fruit and vegetables no longer needed for closed restaurants.

Farmers' markets are so much more than just marketplaces. The plant grower communities that form their foundations are a storehouse of information about local plant biodiversity. Diverse plant populations are often more resilient and environmentally stable, and local farmers tend to grow more diverse plants than larger farms, which increase their profit margins by growing a more limited range of crops in bulk for large-scale sales.

Farmers' markets also serve as plant conservation hubs through activities such as sharing seeds and plant propagules. It is increasingly common to see markets advertise sharing seeds (heirloom tomato seeds are a favourite) or plant cuttings with customers and merchants.

The next time you walk through a farmers' market, make sure to try something new, in addition to finding your regular favourites. Last autumn, I sampled tropical-tasting Michigan pawpaw fruit for the first time, and wondered what had taken me so long. While you wander between stalls, spare some time to take in knowledge about the plants and growers around you – their continued existence depends on it. ▮

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Lightyear Foundation**

Making STEM accessible

Lightyear Foundation breaks down barriers to get more disabled people into STEM. Made up of specialist scientists, leaders and creative professionals, the charity is passionate about helping change the trajectory of disabled children's lives.

Recent years have seen some headway in tackling science's inclusivity and diversity issues but it's still work in progress. One significant subsection of society – that makes up 20% of working-age adults – remains largely overlooked, and that's disabled people.

The good news is that there's a growing realisation that a homogeneous workforce tends to come up with narrow-focused solutions. To overcome the big global challenges, our scientists and engineers of the future need to come from all walks of life.

78% of the Autistic Community and 95% of people with a learning disability are unemployed yet many 'disabilities' are in fact advantageous. For example an autistic coder may excel at attention to detail and find comfort in repetition or a visually impaired scientist could detect tactile details that someone else might miss.

The 'Jobs of the Future' study revealed that science, research, engineering and technology jobs will grow at double the rate of other occupations creating 142,000 extra jobs between now and 2023. With a severe lack of employment opportunities for disabled people and still currently underrepresented in the STEM workforce, we need to mobilise this untapped pool of talent.

Lightyear Foundation uses a unique five-part programme to excite, inspire and enable disabled children (such as those with autism, visual impairment, cancer or cerebral palsy) to access STEM.

From immersive, creative sensory workshops using science to teach life skills, 'Virtual Lab' – an online exploratory, accessible Work Inspiration Trips and a Role Model programme, Lightyear Foundation offers a progressive and holistic approach. This helps the charity reach young people who show potential in STEM learning and deliver opportunities that empower them to take their next steps whether that be using science to teach life skills or for others who can go onto achieve a formal qualification in science or pursue a STEM career.

To help amplify its impact, Lightyear created a SEN in STEM Network (Special Educational Needs in STEM), a widespread community of people committed to making STEM accessible. Building on its expertise it creates opportunities to share, learn and showcase across the 200 member organisations who collectively represent the UK's science community.

Want to get involved?

Join the SEN in STEM Network:
linkedin.com/groups/8903108/
lightyearfoundation.org
Registered Charity No. 1150231

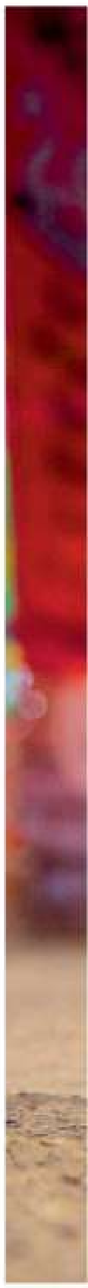
[1] https://researchbriefings.files.parliament.uk/documents/CBP-7540/CBP-7540.pdf

[2] https://www.autism.org.uk/what-we-do/news/new-data-on-the-autism-employment-gap

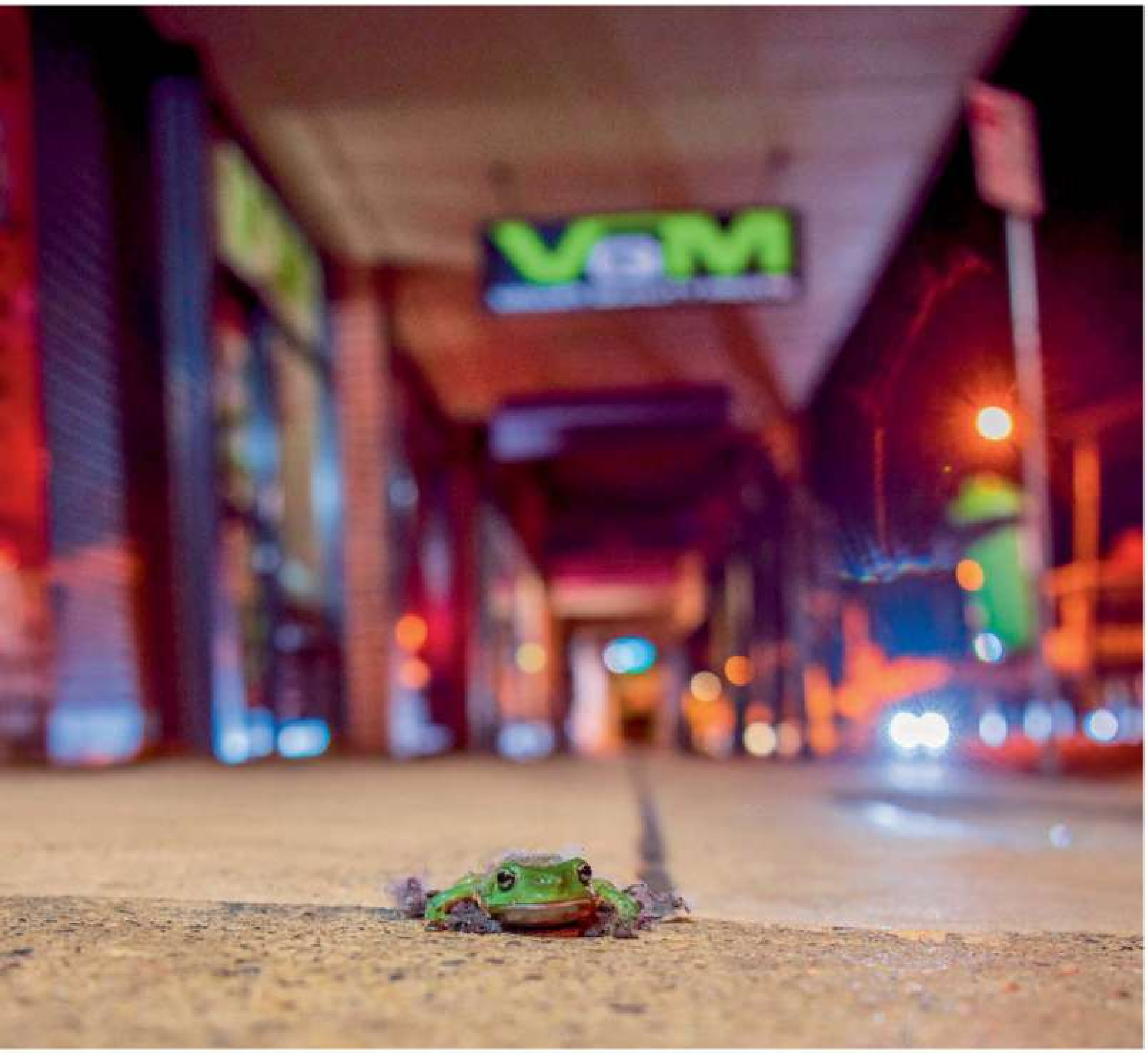
[3] https://www.mencap.org.uk/learning-disability-explained/research-and-statistics/employment-research-and-statistics

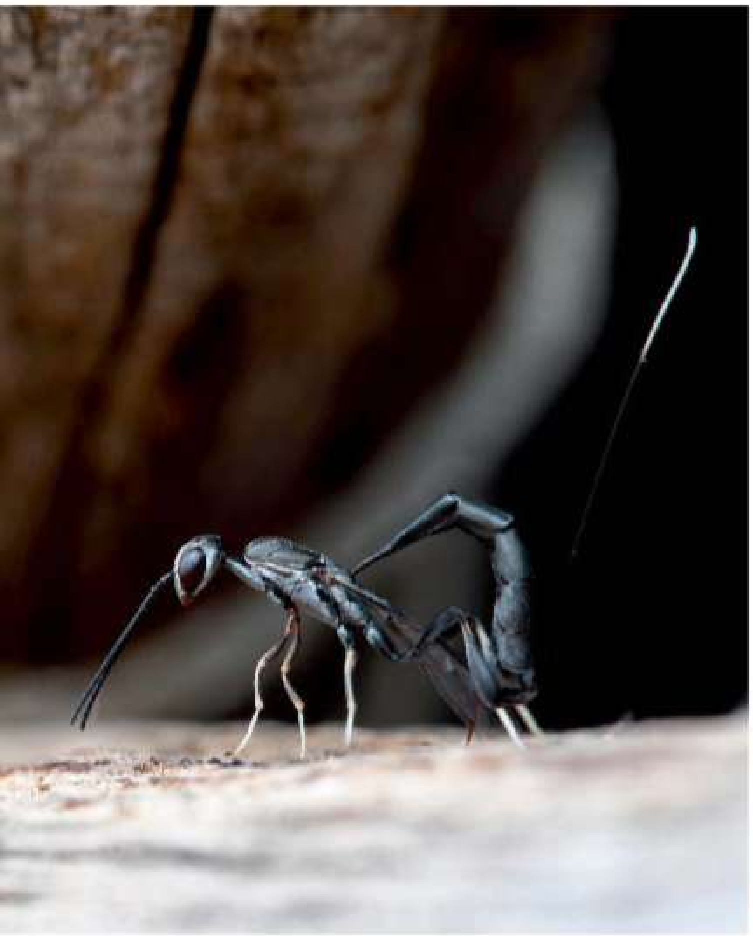
[4] https://www.sciencecampaign.org.uk/resource/jobs-of-the-future---social-market-foundation--edf-energy.html

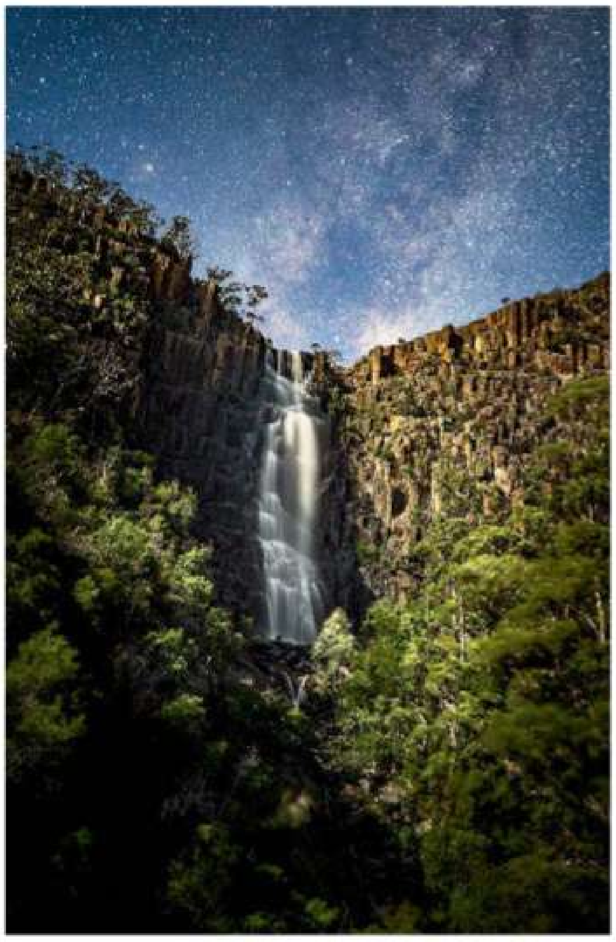
Do you need your signal boosted?
If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com



CLOCKWISE L-R: SIMONE CAPRODOSSI; PETER ABERY; LUKE TSCHARKE; JAMES DOREY; BEN GOODE







Natural wonders

THIS celebration of the landscapes and wildlife of Australia is drawn from some of the shortlisted entries for the Australian Geographic Nature Photographer of the Year 2022 competition. Simone Caprodossi's shot of a young green turtle snacking on a lion's mane jellyfish at Byron Bay in New South Wales – top left, titled *Jelly Floss* – was shortlisted in the Animals in Nature category. Caprodossi likens the turtle to a child consuming candy floss; he managed to capture it, in its eagerness to eat, with the jellyfish wrapped around its face like a veil.

A green tree frog takes a pre-dawn stroll along a pavement in downtown Bellingen, New South Wales, in the image *Feeling A Bit Green* (top right) by Peter Abery, shortlisted in the Urban Animals category. "I put my camera on the ground to get the perspective I wanted," said Abery.

In *Star Fall* by Luke Tscharke (bottom right), shortlisted in the Astrophotography section, the Milky Way is a twinkling backdrop for the Pelverata Falls in Tasmania.

The bottom middle image, *The Long Lady*, by James Dorey, is on the Animals in Nature shortlist. It shows a female ghost wasp in Mitcham, South Australia, that lays larvae in bee or wasp nests, which then feed on both their hosts and any food stored in the nest. "This lady is just doing what's best for her children," said Dorey.

Benjamin Goode took the shot shown bottom left on the Tasman Peninsula coast – titled *Fantasy* and on the Landscape shortlist – while humpback whales breached around him. "The landscape photographer in me couldn't resist taking a few moments to capture the stunning coastal scenery," he said. Winners will be announced in August. ▮

Gege Li

Editor's pick

Keep robots shiny and metallic, not skin-covered

18 June, p 22

From Elizabeth Belben, Nettlebridge, Somerset, UK

You report that Shoji Takeuchi at the University of Tokyo thinks it is important that we make robots look more human so that we feel comfortable interacting with them.

I would feel more comfortable if a robot was identifiably robotic than if it looked human – and definitely more than if it was coated in human skin, as Takeuchi foresees.

Considering the ethical minefield created by chatbots that may or may not be sentient (18 June, p 9) and online "influencers" designed to manipulate people by giving the impression of being sentient (11 June, p 47), what would make me more comfortable is clarity about who is a sentient being with feelings and rights, and what is a machine that we can turn off.

To truly make an AI, we must send them to school

28 May, p 16

From John Andreae, Lower Hutt, New Zealand

Your article "A breakthrough moment for AI?" is yet another showing that deep learning is producing amazing examples of intelligence, but it is on the wrong track for an artificial general intelligence (AGI). Computer scientist Melanie Mitchell, among others, has pointed out that an AGI must have an education like ours in order to learn from us and understand the world in the way we do. This isn't far off or unrealistic. It is within our grasp.

Not sure if I would take up residence in a biosphere

4 June, p 27

From Sam Edge, Ringwood, Hampshire, UK

It occurs to me that artificial biospheres such as MELiSSA are flawed, in that they are too fragile because they are too simple.

If my life were at stake, I would be much happier if a single point of failure couldn't spell doom for the whole system. This would require dozens or possibly hundreds of diverse living components, in parallel with multiple redundant electro-mechanical systems.

Widen the search for the real causes of things

28 May, p 44

From Robert Checchio, Dunellen, New Jersey, US

Researchers Erik Hoel and Renzo Comolatti may be correct in asserting that causality is found at a higher level than the quantum, but the real trick might be in determining how large an area you should search to find the true cause of a particular effect.

To continue the scenario that opened the article, the striker who scored the goal perfectly may be congratulated for their efforts, but the ultimate cause could easily be the four extra ales the defenders drank the night before. The resulting hangovers could have slowed their reflexes so much that they were unable to respond effectively to the midfielder's superb pass, allowing the striker to receive the ball unchallenged.

From Judith Graham, Millbrook, Ontario, Canada

Any claim that the issue of free will is addressed by causality emerging at levels above quantum mechanics makes no sense. Just moving causality from one level to another doesn't change the observation that if there is causality, there is predestination.

As noted in the article, adding randomness to the system from which causes emerge doesn't add free will either. Free will is an illusion that we would do well to recognise as such.

As in Virunga, so in Uganda

11 June, p 42

From Keith Collyer, Reading, Berkshire, UK

The article on gorillas in Virunga was fascinating. I couldn't help noticing the similarities between the work being done there and that being led by Gladys Kalema-Zikusoka in Bwindi, Uganda. She was one of the first to recognise the three-way relationship between gorillas, humans and livestock in terms of disease transmission and sharing the environment. She was recently honoured with the Edinburgh Medal at the Edinburgh Science Festival for this work.

Lessons from the Nordic experience with STEM

21 May, p 27

From Geoff Harding, Sydney, Australia

Maria Rossini writes about the subject of women in STEM. After a gender imbalance develops at the high school, undergraduate or postgraduate level, it can be self perpetuating because girls and women might not enjoy studying and working in male-dominated environments, where social and academic support may be lacking.

During a sabbatical in the physics department at Uppsala University in Sweden in 1998, I was surprised to find the proportion of female research students was roughly 50 per cent. Obviously the gender equality of the Nordic countries encourages an attitude that girls can successfully pursue careers in anything, including STEM, and if they do they will have many female associates. The secret to this appears to be gender equality from the earliest age.

UK talent visas seem so blinkered

4 June, p 15

From David Muir, Edinburgh, UK

You report the UK government is introducing a talent visa to lure graduates from top universities into the country. I was worried to read that anyone studying at a university in Africa, Central or South America or South Asia wouldn't be considered eligible for this visa.

The Home Office seems to base its ratings for universities on inappropriate and anachronistic criteria.

Statue of Liberty isn't a standard measure

4 June, p 12

From Simon Goodman, Griesheim, Germany

As much as we, your readers, relish your impartial internationalism, I for one am peeved by the use of a particular unit of measurement – the "Statue of Liberty"– in your look at space start-up SpinLaunch. Is this more or less than a Nelson's Column, an Eiffel Tower, a Petronas Tower or a blue whale?

I think some wise people had a good idea some time ago to create standard units, like the metre, which, relatively speaking, have stood the test of time.

Call off the search for new name for lab-grown meat

Letters, 28 May

From Martin Pitt, Leeds, UK

There is no need to search for a new name for animal cells grown in vitro for food. Cells being grown in the lab or in industrial vats are referred to as cultures. Cultured meat is what Wikipedia calls it, and this term is widely used. ▮

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Bridging the great divide

The argument that it is possible to find common ground with those holding diametrically opposing views is a tonic, finds **Chris Stokel-Walker**

Book

How Minds Change: The new science of belief, opinion, and persuasion
David McRaney

Oneworld Publications

AMID increasingly entrenched views on politics, economics and how to deal with the pandemic, there seems to be a growing tally of potential conversational minefields to navigate. More than ever, it seems as if we are stuck in our own ways, unable to see another point of view – let alone trying to bring someone round to our own argument.

But don't give up hope yet, is the message of science journalist David McRaney's second book, *How Minds Change*. His first, *You Are Not So Smart*, was based on a popular blog and spawned an associated podcast. This time, McRaney is arguing that even though it may seem as if we are unable to find common ground with those who hold diametrically opposed viewpoints, we can do this. And more than that: we are able to get such people to see our point of view.

McRaney tries to unpick the science and synaptic responses that go on behind Damascene conversions – for example, the everyday words and deeds that can trigger a change of mind in someone who believes strongly that members of the LBGTQ+ community shouldn't have the same rights as straight people.

He does so mostly not by running through a dry list of scientific research, but by fly-on-the-wall insight: some of the most compelling chapters follow canvassers supported by University of California, Los Angeles (UCLA), neuroscientist-as they campaign for LBGTQ+ rights in California, working on scripts and prompts to successfully persuade people to loosen their opposition to equal rights for all.

ANDRE PENNER/AP/SHUTTERSTOCK

A gay pride parade in São Paulo, Brazil, in June this year

Those accounts are some of the most interesting, not least because – as in real life – they aren't black and white. The UCLA research is tainted by missteps in procedure that nullifies the results scientifically; those on the ground still swear it works, however, and it seems to, but the exact salient steps are difficult to discern because of procedural issues.

The book is full of such vignettes: McRaney spends time with former members of the Westboro Baptist Church in the US, described by the Southern Poverty Law Center as "arguably the most obnoxious and rabid hate group in America", learning how they came to disavow their vitriolic beliefs and become more beneficent towards others. The answer, he finds, isn't willing people to come around to your point of view, but letting them realise the folly of their ways.

> "Firmly held beliefs about the way the world works can change if we get more information"

We also encounter less significant, but more foundational, errors in judgement that humankind has previously made. Through these shifts in beliefs, we can see how today we can learn to admit our misconceptions of the world and how it works.

For example, until around 1000 years ago, people truly thought that certain geese didn't hatch from eggs, but grew on trees, birthed from barnacles that looked a lot like a goose's head. That is an indication of just how much firmly held beliefs about how the world works can change with more information.

The concept – that, with more knowledge, long-held hypotheses can be disproved – isn't likely to be news to *New Scientist* readers. But it doesn't make McRaney's book any less interesting. Indeed, his writing is a tonic for those who might scratch their head at how others could be so nonsensical as to distrust vaccines, believe the Earth is flat or subscribe to any other number of conspiracy theories. It helps shift perceptions from the unhelpful attitude of "this person is stupid and beyond help" to "this person has a different frame of belief, and they can be encouraged to think more deeply about the issue".

Because that is the big discovery of those Californian campaigners and the neuroscientists behind them: simply shouting facts at disbelievers doesn't change their minds, rather it entrenches their belief – as anyone who has tackled a tricky dinner table conversation will know. Instead, to change minds, you have to not change minds at all. You have to let people come to their own conclusions – though, of course, you can help them get there by posing the right questions. ■

Chris Stokel-Walker is a technology journalist based in Newcastle, UK

Join Frank Close to learn more about Peter Higgs and his boson at New Scientist Live on 8 October
newscientistlive.com

A very particular story

A brilliant book about the discovery of the Higgs boson isn't for the faint-hearted, finds **Simon Ings**

Book

Elusive: How Peter Higgs solved the mystery of mass

Frank Close
Allen Lane

IN HIS latest book *Elusive*, physicist Frank Close sets out to write about Peter Higgs, whose belief in the detectability of a very special particle that was to bear his name earned him a Nobel prize in 2013.

But Higgs's life resists narrative. He has had a successful career. His colleagues enjoy his company. He didn't over-publish or get into pointless spats. Now in his mid-nineties, Higgs keeps his own counsel and doesn't use email.

So that left Close with writing a biography not of the man, but of "his" particle, the Higgs boson – and with answering key questions, such as how do we explain fundamental forces that can't reach outside the nucleus of an atom? What was so compelling about our explanation it was worth inventing a fundamental field we couldn't detect? Why did this idea occur to six thinkers, independently, in 1964? And how did it justify a cool €10 billion to hunt for the particle that this conjectural field predicted?

It is all in Close's excellent book, but you have to work hard. Let's start with our universe. Forget solid matter for a moment, think fields. The universe is full of them, and if we disturb these fields it is as though we dropped a stone into a lake – we make waves. In this analogy, which is a favourite of the physicist Sean Carroll, there is no "outside" from which you can see the whole wave. Instead, as the wave passes through a point in space, you will notice a fluctuation in energy at that point.

> "We need a mathematics to explain why the other fields we know about are infinitesimally small"

These changes show up as particles. Light, for example, is a wave in the electromagnetic field, yet when we observe the effect that wave has on a point in space, we detect a particle – a photon. Some waves are easier to make than others, and travel farther. Light waves travel outwards as fast as the universe allows. Gravitational waves are just as fast, but decay sharply with distance.

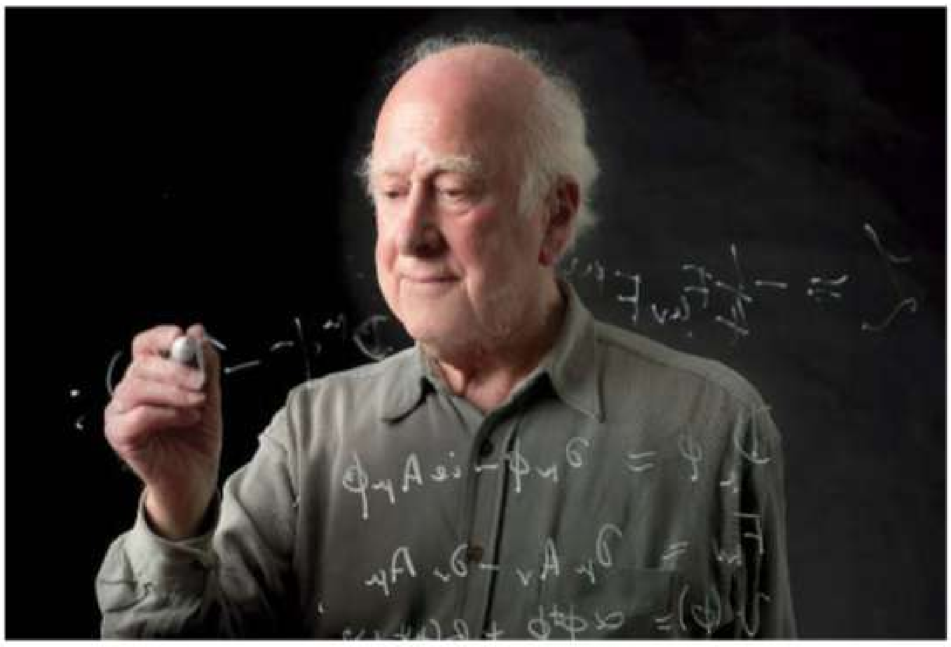
The mathematics used to model such fields makes sense. But we also need a maths to explain why the other fields we know about are confined to infinitesimally small spaces, extending no farther than the dimensions of the atomic nucleus. For this maths to work, it requires another, more mysterious, infinite field: one that doesn't decay with distance, and that always has a value greater than zero. This field interacts with everything bar light.

We call the effect of this field mass. Photons are massless, so travel very fast, while everything else has some mass and therefore travels more slowly. It is easy to set the electromagnetic field trembling – just light a match. To set off a wave in the mass-generating field, however, takes much more energy.

In 1998, CERN, the world's largest particle physics lab, began work on its Large Hadron Collider (LHC), a 27-kilometre-long particle accelerator below the French-Swiss border. More than a decade later, on 4 July 2012, a particle collision in the LHC released such energy that it set off a mass-generating wave. As this wave passed through the machine's detectors, a new particle was observed. Physicists confirmed the existence of the mass-generating field and our model of how the universe works (the standard model) was completed.

Ultimately, both Higgs and his particle remain elusive. Newcomers should start elsewhere – perhaps with Carroll's fine webinars and books. But Close, and this difficult, brilliant book, will be waiting. ▮

Simon Ings is a writer based in London. For more on the Higgs boson, turn to page 42



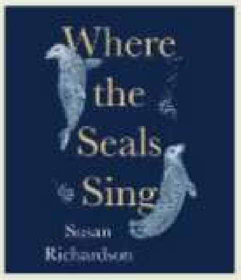
Peter Higgs received a Nobel prize for his prediction of the boson named after him

CLAUDIA MARCELLONI/CERN

Don't miss

Watch

Dr. Who and the Daleks and **Daleks' Invasion Earth 2150 A.D.** are 1960s classics directed by Gordon Flemyng and starring Peter Cushing. They have now been regenerated in 4K by StudioCanal. Watch in UK cinemas from 10 July.



Read

Where the Seals Sing is also where you will find Susan Richardson, following grey seals as their numbers dwindle all around the English coastline. She records their ways of life, means of survival and the myths that surround them. Available from 7 July.

Visit

Good Natured, a festival of short films that offer hope for the environment among the prevailing stories of loss and destruction, will take over the Oxford University Museum of Natural History from 6pm BST on 8 July.

TOP: ALBUM/ALAMY

The sci-fi column

Bring on the new What would the world be like if men suddenly disappeared? That is the premise of a new science-fiction novel from Sandra Newman that leaves us wondering what it really takes to change history, says **Sally Adee**

Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally_adee

Book

The Men

Sandra Newman

Granta

Sally also recommends...

Books

City of Orange

David Yoon

G.P. Putnam's Sons

Like the film Memento, *but you are trying to piece together how the world ended.*

A Mirror Mended

Alix E. Harrow

Tordotcom

Zinnia Gray solves the problems of princesses and is getting bored of the repetition, when suddenly a villain asks for her help. Part feminist interpretation of a folk tale, part excellent beach read.

MADS PERCH/GETTY IMAGES

A kind of biblical rapture has excised all men from the world in *The Men*

WE ARE hallucinating all the time, according to neuroscience research. Our brains constantly tease comprehensible patterns out of a million sensory inputs – from buzzing bees to approaching animals. This isn't reality, but a good prediction of what reality should be, informed by past experience. While it is an efficient way for the brain to generate the feeling of consciousness, it also means we are like passengers facing backwards on a train – the world, and all its possible futures, can only be pieced together from what has recently passed.

In her new book, *The Men*, Sandra Newman is very concerned with the past and how it tailors our ability to create the future. "The truth is, history is more like physics," says one protagonist, presidential candidate Evangelyne Moreau, in a campaign speech. "The world is made of it. We're made of it." But some kind of biblical rapture has now excised all men from the world. So, asks Moreau, pitching a radical new way to organise society, "what does it take to change history?"

The book's premise puts it in a category of science fiction often called "gender dystopia". But this genre wasn't pessimistic at first – early entries were meant to be road maps to utopia. The first of these, written in the mid-20th century, had a feminist battle cry. Wouldn't the world be better if we got rid of the men? "The problems ended when you did," say women of the future to time-travelling male astronauts in *Houston, Houston, Do You Read?* (written by Alice B. Sheldon under the pseudonym James Tiptree Jr).

> **"Newman is very concerned with the past and how it tailors our ability to create the future"**

More recent entries were less convinced that a woman's world would be so much better. In Naomi Alderman's *The Power*, women attain an ability that gives them physical dominance, but it turns them venal and militant – making the case that men's bad behaviour throughout history isn't an essential feature. Give the same advantages to a woman, and you would just get a toxic matriarchy.

Lauren Beukes comes to a similar conclusion in *Afterland* – here, men contract an oncogenic virus that causes untreatable cancer – but she focuses on the inescapability of the systems we have established. Women fill the absences in the military, sending society back into motion barely perturbed. Even Nazi biker gangs are swiftly repopulated. The bottom line in both books seems to be that human nature and institutions transcend gender.

Newman's conclusion in *The Men* is a lot more unsettling and fundamental, in line with her idea that the future is stitched together from scraps of the past. History is a fundamental limiter for future behaviour. "We gotta change!" the women scream after Moreau's speech. But can they? Newman's refutation comes in the form of Jane, Moreau's lover. When there were men, Jane was a man's wife. Now, she has become a woman's wife. "Maybe everyone, to optimally function, needs a wife," she thinks. And wife is the role Jane has stitched for herself from the remnants of the past.

Perhaps Newman is right and we all curate our futures this way. On the campaign trail, Jane reaches an epiphany: "We have no real face; they are masks that are borrowed and passed on, that live for millennia, and are what a human is." After that, the book moves quickly to its conclusion, and Newman makes it clear that on a foundation of history, all you can do is rebuild the past. ▮

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BRETT RYDER

Age-defying food

There is no shortage of advice about healthy eating, but is there really a diet that can make you live longer? **Graham Lawton** reports

I HAVE seen my future and it is full of beans, both literally and metaphorically. As well as upping my bean count, there will be a lot of vegetables, no meat, long periods of hunger and hardly any alcohol. But in return for this dietary discipline, my future will also be significantly longer and sprightlier. I am 52 and, on my current diet, can expect to live another 29 years. But if I change now, I could gain an extra decade and live in good health into my 90s.

This "longevity diet" isn't just the latest fad, it is the product of more than a human lifespan of scientific research. And it isn't merely designed to prevent illness, but to actually slow down the ageing process – that's the claim, anyway.

Of course, it is a no-brainer to say that our diets can alter our lifespans. Worldwide, millions of people still die prematurely every year from lack of calories and nutrients. Meanwhile, an estimated 11 million die each year from too many calories and the wrong sort of nutrients. Scoffing more than we need inevitably leads to obesity and its pall-bearers, cardiovascular disease, diabetes and cancer. Typical Western diets are also high in sugars, refined starches and saturated fats and low in wholefoods, which add insult to injury by disrupting metabolism. That includes the excessive release of insulin, the hormone that keeps blood sugar levels under control and has a direct impact on ageing. Suffice to say that Western diets don't push the longevity lever in the right direction. But is it really possible to eat oneself into a later grave?

In the US, between 1970 and 2009, average daily calorie intake rose by 20 per cent, to 2520 kilocalories. Other Western countries have followed that trend. The shocking extent to which our obesogenic, disease-promoting and pro-ageing diets are shortening our lives was revealed in recent work from the University of Bergen in Norway. Researchers led by Lars Fadnes modelled what would happen to people who switched from a typical Western diet to their optimal one containing more wholegrains, fruits, vegetables, nuts, legumes and fish and less meat, dairy, refined grains and sugary drinks (see "Optimising your diet", page 40). Based on data from a huge research project called the Global Burden of Disease study, which, among other things, analysed diets and diet-related illnesses across 195 countries, they found that Westerners could typically buy themselves a lot more time.

Switching to this optimal diet at age 20 and sticking to it would extend average life expectancy by more than 10 years for women and 13 years for men. And it is never too late: 60-year-olds shifting to this diet would gain eight years of life expectancy and 80-year-olds an extra 3.4 years. Even a diet that is a halfway house between a typical Western one and the team's optimal one would add six to seven years if adopted at age 20. These surprisingly large responses are probably because the diet immediately improves metabolic health, says Fadnes. "We haven't gone into the mechanisms, but our hypothesis is that the longevity expectations are linked to reduction in cardiovascular disease and, to some degree, reduction in the risk of cancer," he says.

> **"Researchers believe we can hack our biology to slow the ageing process"**

In other words, a healthy diet can prevent diseases linked to a bad diet. Who knew? However, for decades, many researchers have believed we can do even better, by hacking our biology to actually slow the ageing process.

The first inklings came over a century ago. In 1917, researchers at the Connecticut Agricultural Experiment Station in New Haven discovered that female rats that had been starved as pups subsequently stayed fertile longer than average and lived to a ripe old age. Further experiments confirmed that this "caloric restriction without malnutrition" – achieved by cutting calories by up to 60 per cent while supplementing the diet with vitamins and minerals – kept mice and rats healthy and alive for longer. The earlier it was started and the more stringently it was applied, the greater the gain.

Caloric restriction has since been shown to be capable of extending healthspan and lifespan in every organism it has been foisted on, including yeast, flies, worms and primates. The results vary widely, but some of the gains in lifespan are spectacular. Mice on caloric restriction, for example, can live up to 50 per cent longer than average – which would translate to about 120 years if replicated in humans.

But can it be replicated in humans? Unfortunately, doing human caloric-restriction experiments is extremely difficult. Not only do people find it very hard to halve their energy intake for more than a few days at a time, but the experiment would also have to run for many years to assess whether it had any life-extending effect. "In people, we don't even really know that caloric restriction has long-term significant health benefit," says Matt Kaeberlein at the University of Washington in Seattle. And we do know that it can seriously damage the health of people who limit their caloric intake as a result of eating disorders. It is important to note that no one should restrict their diet to the extent that it damages their health.

Nevertheless, there are reasons to believe that caloric restriction would extend lifespan in people. One is basic biology. It turns out that, regardless of species, the mechanism by which caloric restriction exerts its life-extending effects is essentially the same: a network of metabolic pathways that assess the

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availability of nutrients and respond by toggling cells between two biological states, feast and famine. When nutrients are plentiful, these pathways stimulate cells to grow and divide. When they are scarce, cells are told to hunker down and await better days. "We see most organisms going into a maintenance mode and not ageing very much," says Valter Longo at the University of Southern California in Los Angeles.

Crucially, part of that process is to sweep up intracellular debris, such as damaged molecules and organelles, to burn as fuel, a bit like throwing bits of broken furniture onto the fire. This detritus is a direct cause of the cellular damage that results in ageing, so destroying it – a process called autophagy – prevents such damage from occurring. Starvation also boosts repair processes, which can reverse damage that has already been done.

WESTEND61 GMBH/ALAMY

An optimal diet would include more vegetables than most people eat

Feast or famine

One key player in this nutrient-sensing system is the insulin receptor. When insulin is released in response to a spike in blood glucose, this cell-membrane protein switches on and helps turn the system to growth and reproduction. It does this in part by activating another nutrient sensor called mTOR, which is the linchpin of the feast-famine system and is of intense interest in anti-ageing circles. When mTOR is on, autophagy and repair switch off. So if glucose is constantly flooding into the bloodstream, the insulin receptor gets stuck in the "on" position and mTOR is chronically activated.

Animals subjected to caloric restriction show increased sensitivity to insulin, along with improved liver function and loss of weight and body fat. All these biological indicators were also seen during a rare human trial called CALERIE (Comprehensive Assessment of Long-Term Effects of Reducing Intake of Energy) in which people consumed 25 per cent fewer calories for up to two years. This is another reason for optimism about human caloric restriction, but it still doesn't get around the fact that the regime is very hard to stick with.

However, there is some evidence that less-onerous diets have similar effects – at least in mice. Many involve restricting calories some of the time, such as periodic fasting, which entails eating next to nothing for two days each week, or every other day, or for up to four consecutive days a month. Another is time-restricted eating, such as the 16:8 diet, when all the day's calories are consumed in an 8-hour window bookended by 16-hour fasts. Both these types of diet are sometimes called intermittent fasting. A third approach is the fasting-mimicking diet in which, for a period of five days a month, individuals eat a plant-based meal plan low in sugar, carbs and calories but high in fat that is designed to evoke the fasting response without total abstinence. (Longo holds patents related to fasting-mimicking diets and has equity in a company that sells them.)

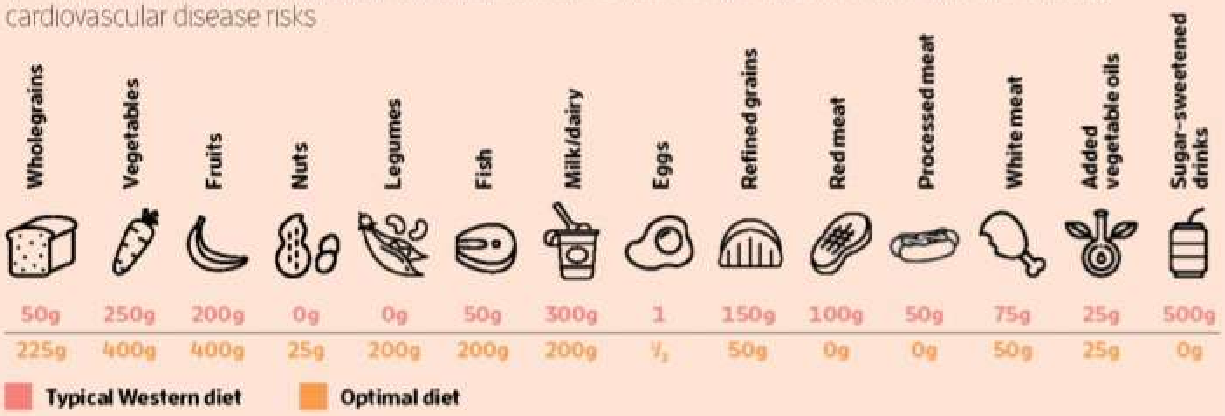
Other diets that promote longevity in rodents don't even require fasting, but these are more complicated to follow. Protein restriction, for example, is based on reducing the calories obtained from protein from the normal 10 to 15 per cent to around 5 per cent, with the calories replaced by carbohydrates. More elaborate still is amino-acid restriction, which limits consumption of some of the building blocks of proteins. The main target is ethionine, found mostly in animal proteins, with cuts of 80 per cent or more required. Another is tryptophan – sources include milk, chicken and oily fish – which must be reduced by about 40 per cent. Cutting branched-chain amino acids such as leucine, isoleucine, and valine – mostly found in meat, dairy and cereal – by two-thirds also works. These restrictions appear to exert their effect through mTOR, though exactly why the body responds in that way isn't clear.

Such interventions are generally less effective than full-on caloric restriction. Protein restriction, for example, extends mouse lifespans by about 15 per cent compared with 50 per cent, while time-restricted feeding gives about a 10 per cent boost. But the fact that they are easier has led to claims that they can be directly applied to humans. The past few years has seen a torrent of questionable anti-ageing diets based on this research, says Kaeberlein. "When people start recommending these dietary interventions to the general public, they're doing so in the absence of any real data suggesting that it's beneficial, beyond the benefits you get from not being overweight."

Now, however, such claims are finding their way into the scientific literature. In April, the prestigious journal *Cell* published a review paper containing a "longevity diet... to optimize lifespan and healthspan in humans". The authors – Longo and Rozalyn Anderson at the University of Wisconsin-Madison – blended decades of research on the biology of ageing, the effects of caloric restriction and similar dietary

Optimising your diet

Switching from a typical Western (TW) diet to an optimal one (OD), as defined by researchers at the University of Bergen, Norway, can add a decade or more to life expectancy, mainly by reducing cardiovascular disease risks



	Wholegrains	Vegetables	Fruits	Nuts	Legumes	Fish	Milk/dairy	Eggs	Refined grains	Red meat	Processed meat	White meat	Added vegetable oils	Sugar-sweetened drinks
🟥 Typical Western diet	50g	250g	200g	0g	0g	50g	300g	1	150g	100g	50g	75g	25g	500g
🟧 Optimal diet	225g	400g	400g	25g	200g	200g	200g	½	50g	0g	0g	50g	25g	0g

You can calculate your own life-expectancy dividend from switching to a healthier diet at **food4healthylife.org/**

SOURCE: PLoS Medicine, vol 19, p e1003889 doi.org/10.1371/journal.pmed.1003889

The longevity diet

Research published in April identifies six steps designed to increase lifespan by promoting lean body mass and healthy blood sugar levels, switching off the body's central pro-ageing system and ramping up an anti-ageing process called autophagy:

1 **Limit calorie intake to maintain a body mass index of 22 to 23 for men and 21 to 22 for women.**

2 **Eat a diet high in wholegrains, legumes and nuts. Stop eating meat to restrict intake of the amino acid methionine, but include some fish.**

3 **Aim to get between 45 and 60 per cent of calories from non-refined complex carbohydrates, 10 to 15 per cent from plant-based proteins and 25 to 35 per cent from plant-based fats.**

4 **Do a limited daily fast, eating no calories from around 3 hours before bedtime and for the next 11 to 12 hours.**

5 **Every two to three months, undertake five days of complete fasting or a fasting-mimicking diet (see main story).**

6 **Alcohol is allowed in small amounts, but no more than 5 units a week.**

THOMAS BARWICK/GETTY IMAGES

If we can tap into the body's anti-ageing pathways, we can increase healthspan as well as lifespan

interventions, and knowledge on the health benefits of various food groups, including from the recent University of Bergen study. Then, they seasoned it with data on the dietary habits of people living in longevity hotspots such as Okinawa in Japan and Sardinia in Italy. The end product is a diet that could add years to a typical person's life. "It's going to be associated with a huge effect," says Longo. "You're starting to get into 15 to 20-year changes in life expectancy."

The main ingredients of this longevity diet – which is yet to be tested in trials – are enough caloric restriction to stay slim, a daily regime of very mild, time-restricted feeding, a few five-day cycles of fasting-mimicking each year and a largely plant-based diet (see "The longevity diet", left). This, says Longo, delivers both a conventional healthy diet that guards against obesity and its consequences, and also taps into the longevity-enhancing starvation response. "This is what we know works, based on epidemiology, clinical trials, basic research and centenarian studies," he says.

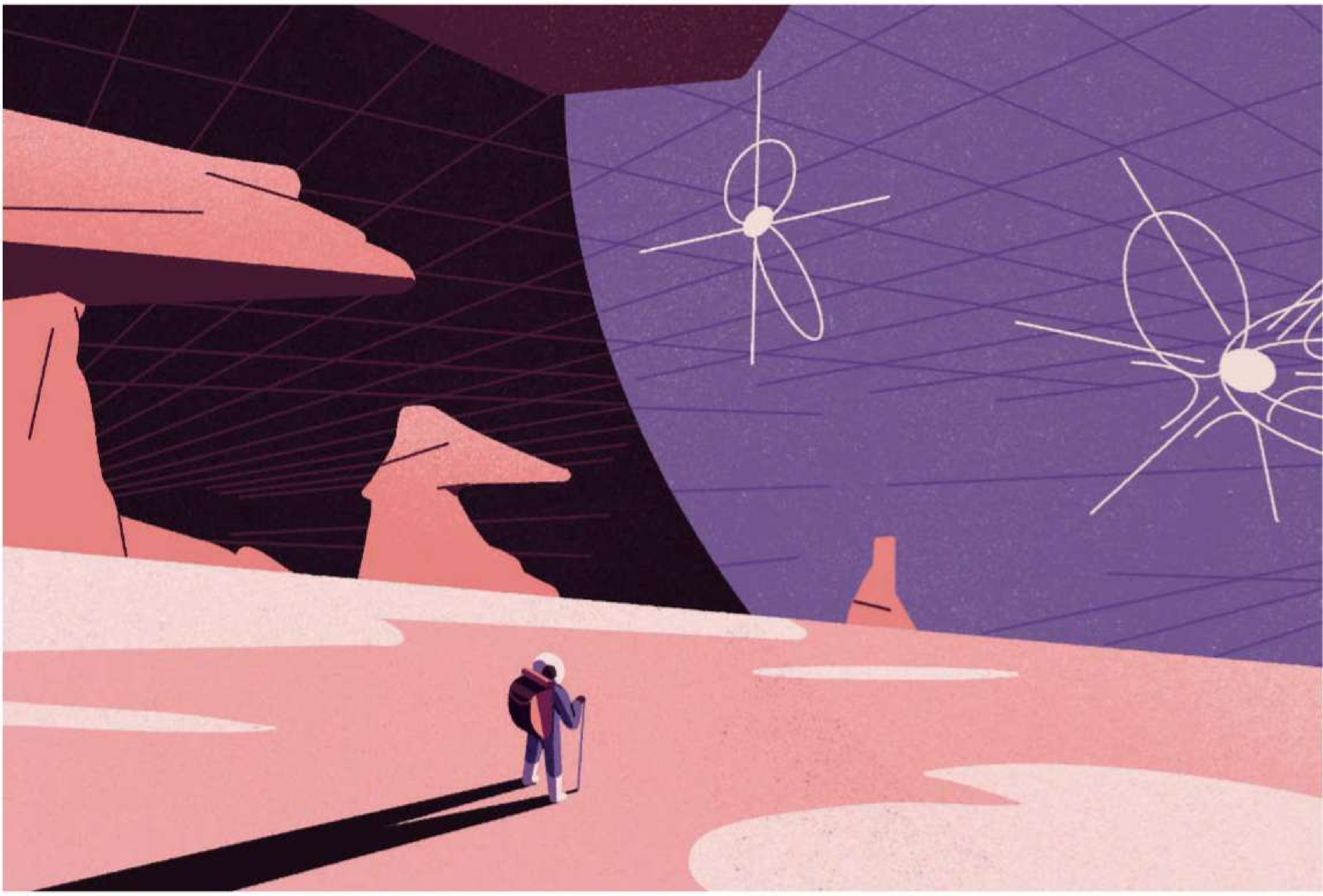
Hold on a minute, says Kaeberlein: even in mice, the evidence for the benefits of time-restricted feeding is slender. "There have been a few studies, but they're almost all short-term – usually eight to 12 weeks – where people claim to see benefits in some cases, and in other cases no benefits. I'd say the body of work is unconvincing." And it is a similar story with the fasting-mimicking diet. This is essentially a period of caloric restriction and, despite a widespread view that such restriction invariably works, that is a myth. Only about half the strains of lab mouse it has been tried on have the "correct" response, some don't respond at all and about a third live shorter, not longer, lives. "We don't really understand why that is," says Kaeberlein, "It's a little bit risky to start recommending these things to the general public when even in mice, a third of the time, it actually reduces lifespan and increases mortality." On top of that, most people who attempt caloric restriction also experience unpleasant side effects, including disturbed thermoregulation, loss of libido and increased susceptibility to infection.

Longo is dismissive of these warnings. "The idea is to keep it very, very safe," he says. He could have recommended something much more hardcore, with caloric restriction, 16 hours of daily fasting and a monthly bout of the fasting-mimicking diet, but deemed it too risky. "Could it help? Yes. But could it hurt? Yes, it could too. So we don't go there."

The proof of the pudding, of course, will be in the eating. Longo has just secured funding to do an 18-month clinical trial in Italy. He will recruit 500 people and put half of them on the longevity diet, leaving the rest on their normal chow, then track biomarkers of improved health and longevity. He doesn't have any doubts it will be safe and effective. In fact, he follows the diet himself and has done for 30 years. But while we wait for those results, it is never too late to start living, so pass the beans. ∎

You should speak with your doctor before changing your diet.

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments and why we're always a bit ill*



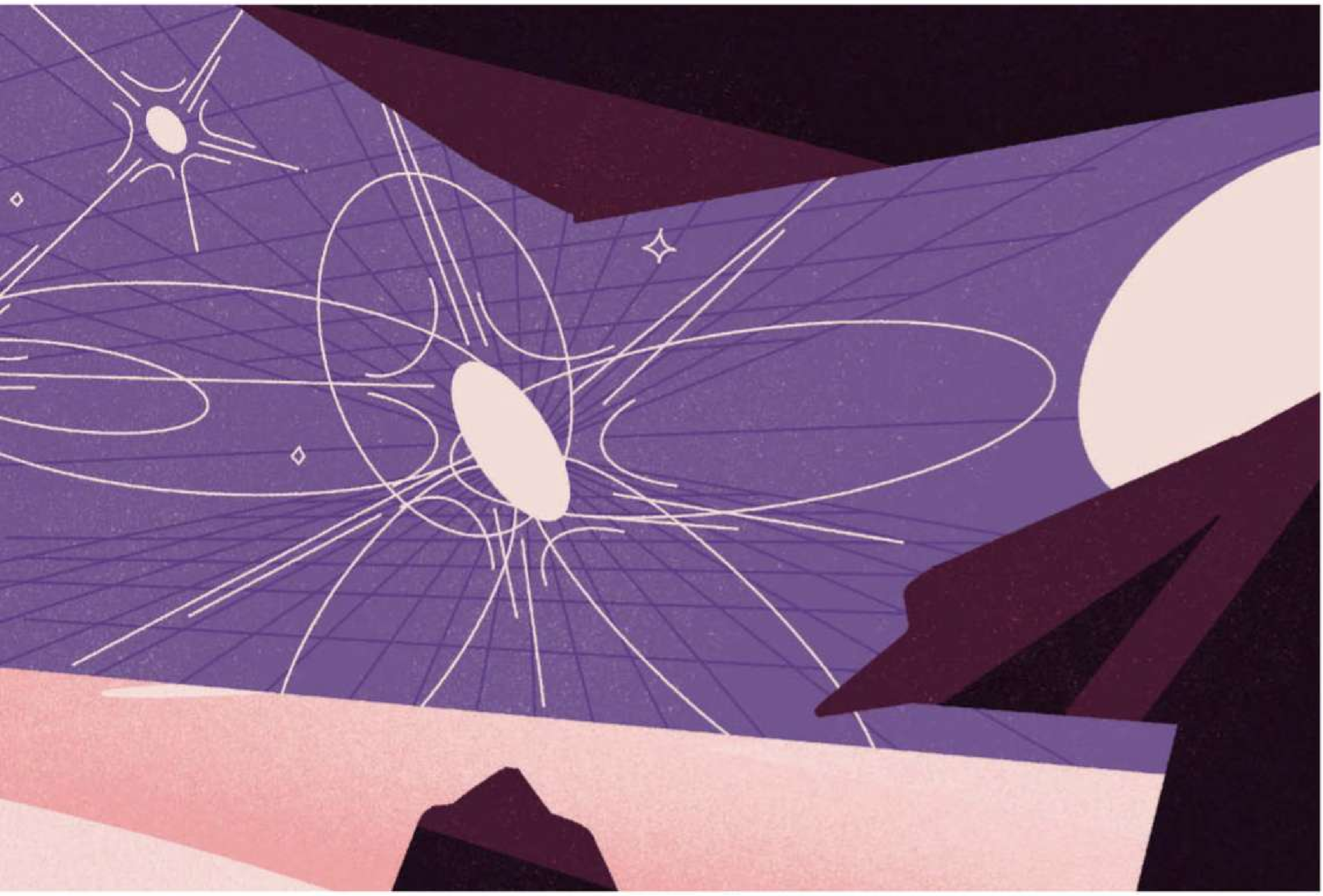
MICHAŁ BEDNARSKI

Uncharted territory

Ten years after the discovery of the Higgs boson became front-page news, particle physics is shaking off a long malaise to begin a new age of exploration, finds **Harry Cliff**

IT'S not unusual to feel worse for wear after a big celebration, but I would bet you've never had a hangover that lasted a decade. Ten years ago, almost to the day, researchers gathered at the CERN particle physics laboratory near Geneva, Switzerland, for the announcement of the discovery of the Higgs boson, the particle that underpins why fundamental particles have mass. It was a huge triumph, both for the mathematical theory that predicted its existence and for the Large Hadron Collider (LHC), which revealed the Higgs by smashing protons together with record-breaking violence.

A fair bit of champagne was drunk at CERN that day. But while the post-celebration lethargy soon lifted, a more lasting malaise has lingered over particle physics ever since. At the time there were good reasons to think the LHC would discover a whole host of new particles that would address some of the biggest mysteries in the universe. But as search after search came up empty, anxiety set in.



"We have a bit of a hangover from the Higgs discovery," says Jon Butterworth at University College London, who works on the LHC's ATLAS experiment. "But we're getting over it."

Now, as the LHC fires up again, there is renewed optimism. We are "off the edge of the map" with no theoretical stars to guide us, says Butterworth, and that is no bad thing. Indeed, the mood among experimentalists like me is one of growing excitement – not only because we already have hints of new physics, but also because there is much data still to come. "So far, we've barely scratched the surface," says Butterworth.

The standard model of particle physics does a stunning job of describing the particles and forces that make up our universe, but we know that it can't be the final picture because, even with the addition of the Higgs, it is manifestly incomplete. Ten years ago, one of the most popular ideas for what might lie beyond the standard model was supersymmetry, known in the field as SUSY, which predicts a zoo of heavy counterparts, or superparticles, for every known particle.

The appeals of supersymmetry were manifold. It was based on a beautiful idea, a mathematical symmetry relating force-carrying particles like photons to matter particles like electrons and quarks. Many SUSY models also contained a stable, electrically neutral particle that was a perfect candidate to explain the mysterious dark matter that dominates the cosmos, keeping galaxies together when they would otherwise fall apart. Better still, with SUSY, the three quantum forces of nature – the electromagnetic, weak and strong forces – appeared to unify at high energies rather precisely.

But perhaps the primary motivation for supersymmetry was that it could stabilise the Higgs boson itself. The Higgs provided firm evidence for the existence of an invisible quantum field that fills the universe: the Higgs field. This acts as a sort of invisible gloop that slows down particles like electrons and quarks, preventing them from zipping around at the speed of light and imbuing them with mass. However, physicists have long been troubled by the fact that the strength of the Higgs field, which determines how massive the particles are, seems to have only two natural values, both of which would be extremely bad news for your existence. In one case, the Higgs field would have a strength of zero, leading to a universe containing a haze of massless particles and not much else; in the other, its strength would be so high that everything in the cosmos would collapse into black holes.

To get the Goldilocks value we observe, the Higgs field has to be extraordinarily carefully fine-tuned, as if some great cosmic tinkerer had set things up just so. And that smells fishy. Supersymmetry solves this problem, with its superparticles interacting with the Higgs in such a way that they stabilise the Higgs field around the value we see without the need for fine-tuning. The trouble is that for this to work, the superparticles must have masses close to ›

“Many theorists are running around like headless chickens”

that of the Higgs boson itself – well within the reach of the LHC. So the fact that none of them have shown up so far is a problem.

John Ellis, a theorist at King’s College London and a leading expert on supersymmetry, earned himself something of a reputation as a SUSY diehard as search after search drew blanks over the past decade. However, he says his focus has now broadened to other topics. “Shares in SUSY have gone down,” he concedes, “but I wouldn’t put them in the junk category.” It is possible that superparticles could still be hiding in the ocean of collision data recorded by the LHC’s ATLAS and CMS detectors. “Most rational investors would put them in the sell category, but I’m hanging on to at least a few of my supersymmetry shares,” he says.

Another possibility that many particle physicists were invested in 10 years ago was the idea that the Higgs itself would reveal something beyond the standard model, for instance by acting as a “portal” to a range of dark matter particles. In the decade since its discovery, physicists at the CMS and ATLAS experiments have put the Higgs under the microscope, measuring its mass and its interactions with increasing accuracy. But so far at least, the Higgs looks remarkably like the version predicted by the standard model, with little evidence for anything more exotic.

All of which explains the long hangover. The lack of new physics has dismayed some, particularly researchers from my (relatively) youthful generation who were enticed into the field by the prospect of a discovery bonanza at the LHC. There have been one or two false dawns over the years, most notably in 2015, when everyone got briefly excited about a tantalising bump in the data that turned out to be a statistical fluke. But broadly speaking, the past decade has been one in which the field has gradually changed tack as physicists moved away from beautiful theoretical ideas like SUSY and listened increasingly carefully to the data.

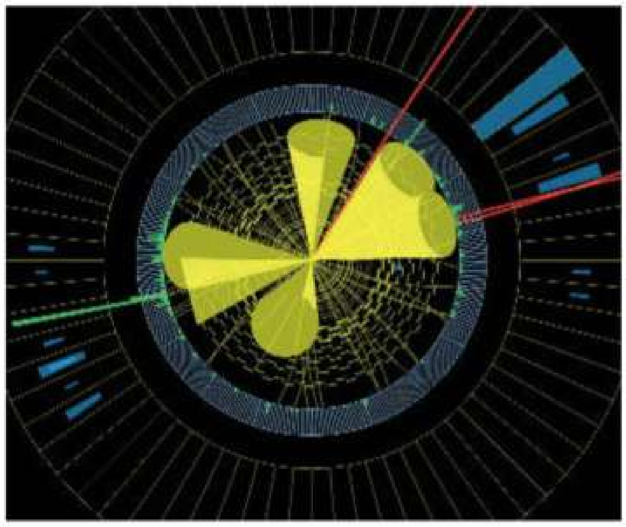
The bonfire of speculative theories has led to a clear shift away from theoretically motivated searches. After the fall in SUSY’s fortunes, no great overarching paradigm has emerged to replace it, says Ellis. “What theory do you invest in? If you look at the theory papers being published, you will see complete confusion. Many theorists are running around like headless chickens,” he says.

Butterworth is pleased by this turn of events. “I would have been a little disappointed if we’d discovered [SUSY] because it would have been just another example of experiment following theory,” he says, before adding with a puckish grin: “And there would have been so many smug theorists around!” Instead, he is excited for what the next decade and a half will bring. That makes sense because, by my calculations, we have only seen roughly 5 per cent of the data we will ultimately get from the LHC in its various iterations.

Intriguing anomalies

Experimentalists are now casting their nets wider. “Ten years ago, we were very focused on two aspects: the discovery of the Higgs and whether supersymmetry exists,” says Val Gibson, a physicist at the University of Cambridge and the LHCb experiment. “It was very narrow. Since then, the field has got a lot broader, which is definitely a good thing.” For instance, over the past decade, my colleagues at LHCb have discovered new types of matter-antimatter asymmetry and exotic new composite particles called tetraquarks and pentaquarks. While these breakthroughs fit within the standard model, they nonetheless provide us with crucial information about the forces and particles that make up our universe.

It is even possible that we are already seeing the footprints of new physics in a series of anomalies identified by the LHCb experiment. The b in LHCb stands for beauty, one of six types of quark. My colleagues at LHCb have recently seen evidence of beauty quarks behaving in ways that the standard model can’t explain. They seem to be decaying to the three electrically charged leptons – the electron, muon and tau – at different rates, something that is forbidden in the standard model, which treats these three leptons identically, apart from the fact that they have different masses.



BRENT YATES/THOMAS MCCAULEY/CMS COLLABORATION/CERN

Collision data from the Large Hadron Collider’s CMS detector

Other measurements have found that the particles produced in the decays fly out at angles that differ from standard model predictions. Tantalisingly, theorists have found that all these anomalies can be explained if a hitherto unknown quantum force is pulling on beauty quarks, changing how they behave.

Anomalies are also cropping up in experiments in the US. In April 2021, the muon g-2 experiment at Fermilab in Illinois reported that the magnetic properties of the muon, a heavier cousin of the electron, disagree with what theorists predict using the standard model. And then, in April 2022, physicists working on legacy data from the CDF experiment at Fermilab’s now-defunct Tevatron collider reported a measurement of the mass of the W boson, a particle associated with the weak force, that was in dramatic disagreement with what we would expect.

These last two anomalies could potentially be explained by superparticles that wouldn’t necessarily have shown up yet at the LHC, offering a glimmer of hope that SUSY could yet rise again. But they could also herald something we have never even thought of, which would arguably be more significant.

Sophie Renner, a theorist at the University of Glasgow, UK, has spent the past few years trying to decode the clues coming from the LHCb anomalies, working on a variety of solutions that generally involve introducing a new type of force particle known as a leptoquark. Leptoquarks can convert quarks directly into leptons and vice versa, something that no standard model particles can do, and could be part of a larger theory that explains why there are six quarks and six leptons in the standard model.

Could there be a connection to the other anomalies from the US? Perhaps, says Renner. “It’s certainly very intriguing that there seem

MAXIMILIAN BRICE/CERN

The upgraded Large Hadron Collider is once more smashing protons together

to be two completely different experiments [muon g-2 and LHCb] that find something weird in muons." She is more sceptical of the W boson mass anomaly: "With the W mass, you can make connections, but it's not obvious, and there's also the issue that the CDF measurement deviates from all the previous measurements. You clearly shouldn't be able to have two measurements of the same thing that don't agree. That's the first question that needs to be understood."

Ultimately, knowing whether these anomalies are the real deal will require more data and new measurements – both of which are guaranteed given the recent restart of the LHC. LHCb has just received a major upgrade and will soon be recording data at around 30 times its previous rate, which should allow us to figure out whether the anomalies are random statistical flukes, missed biases in the experiment or genuine signs of new physics. Likewise, in the coming decade, ATLAS, CMS and LHCb will all be able to make precise measurements of the mass of the W boson.

As for the Higgs itself, there is still plenty of scope for surprises, says Nick Wardle at Imperial College London, who was involved in the discovery of the particle as a PhD student and now leads efforts at CMS to probe it with ever-increasing precision. "Discovering the Higgs was the first step on a long road," says Wardle. "Now we've moved over to using the Higgs as a tool for finding new physics."

One example of how the Higgs could guide us to new physics is if it decays to dark matter. Such a decay would show up in ATLAS and CMS as missing momentum, the sign that something invisible had escaped the detector. In fact, Wardle says that both experiments currently have small hints of just such a decay, though it is far too early to be confident that it is more than a random wobble in the data.

Wardle is also keen to see how the Higgs boson interacts with itself. Such measurements were previously thought to be almost out of reach at the LHC, but, as Wardle put it, "physicists always get smarter as we go", improving their analysis methods to the extent that previously unreachable targets become possible. "I never want to say never. It's completely different what we're able to do with the data compared to 10 years ago," he says.

Measuring the Higgs's interaction with itself would be a huge coup, testing a fundamental assumption of the standard model about how the Higgs comes into existence in the first place. It would tell us about processes in the first trillionth of a second after the big bang that could have been responsible for the origins of matter itself.

The truth is that to pin down whether the Higgs is the same particle predicted by the standard model or something more exotic, we need a collider that goes far beyond the LHC in both size and energy. Physicists have already begun thinking about how they could build such a machine, perhaps by the 2040s. But Butterworth argues that those in the field must not lose sight of what is closer at hand. During the next decade, the LHC will receive a major upgrade to increase its "luminosity" – in effect how many protons smash together every second. This souped-up LHC will unleash a torrent of data and make previously unimaginable measurements possible.

"I think we discounted the High-Luminosity LHC," says Butterworth. "It annoys me to hear fairly early career scientists saying, 'there's all this uncertainty in the field, what should we do'. I say come on! You're talking about what experiment you might be doing in 2040! What other field has a solid future up to 2040?"

The challenge now is to deliver on upgrading the LHC so that we can test the standard model to the highest precision possible. "I'm really excited for the next 10, 15 years of what's going to happen at the LHC," says Butterworth. "Precision and detail may not sound super exciting, but you're searching the undergrowth of a new territory and you may find something really unexpected."

"We're recovering from the hangover," he adds. "I hope the 10-year anniversary will draw a line under some of that." ▮

Harry Cliff is a particle physicist at the University of Cambridge and author of *How to Make an Apple Pie from Scratch: In search of the recipe of our universe*

Engineering the oceans

Could controversial schemes to chemically alter the seas be our best hope to suck carbon out of the atmosphere, asks **Adam Vaughan**

A SPRINKLING of iron ore "glued" onto rice husks using goo from plants hardly sounds like a recipe for saving the planet. Not to mention the fact that the mixture is designed to mimic whale faeces.

And yet if a team of researchers backed by a former chief scientific adviser to the UK government crack this, it could be coming to an ocean near you soon. Theirs is just one of several projects across the world, small in scale but big in vision, looking at a new way to stave off the worst effects of climate change: engineering the oceans.

Similar "geoengineering" proposals are highly controversial, and this idea is no different, horrifying those who warn of the potential unintended consequences of fiddling with sensitive marine environments. But the world's lack of progress on curbing carbon emissions might make it necessary. A recent report from the Intergovernmental Panel on Climate Change (IPCC) on how to tackle climate change made clear that deploying techniques to remove carbon dioxide from the atmosphere will be "unavoidable" if humanity is to achieve net zero carbon emissions around the middle of the century. On land, there are plenty of schemes to do that, from planting trees to machines in Iceland that chemically capture CO_2 so it can be buried deep underground. But getting any of them to the scale we need in time to really make a difference is a tough ask. It could be that we need the oceans, too.

Using the oceans as a solution to climate change is hardly a new idea. A horizon studded with nearly 200-metre-tall wind turbines is already a familiar sight for many people living along the coast of the UK and other countries around the North Sea. Other parts of the world will soon become used to them too. Last year, China installed as much offshore wind farm capacity as the rest of the world did in the past five years.

Yet Earth's great blue expanses could play a far more active role. To avoid global warming breaching 1.5°C, the target the world agreed in Paris in 2015, the IPCC calculated that all forms of CO_2 removal would need to suck 584 billion tonnes of the stuff out of the atmosphere between 2020 and 2100, or just over 7 billion tonnes every year.

For now, planting trees is the cheapest method. But there is only so much land for trees: at most we can squeeze in around a trillion more alongside the 3 trillion we have already, according to one estimate. Terrestrial options for removing CO_2 also often compete with the need to feed almost 8 billion people. The approach considered by the IPCC to have the greatest potential – planting crops that remove CO_2 as they grow and then burning them for energy and capturing the carbon emissions – would require vast tracts of land and huge amounts of water that could have been used for food crops.

In that context, looking to the seas makes sense. "The ocean covers 70 per cent of the Earth's area, so you get a lot more area to work with and can potentially avoid some of the issues that pop up with land-based CO_2 removals," says Katie Lebling at the World Resources Institute, a US-based non-profit organisation.

The oceans already contain 50 times as much carbon as the atmosphere. "If you look at the numbers of CO_2 that need to be sequestered to become carbon neutral by

PÂTÉ

2050 [globally], that's when people realise, OK, we need to include the ocean in this picture," says Ulf Riebesell at GEOMAR, a research institute in Kiel, Germany.

According to some estimates, ocean-based technologies might remove as much as 100 billion tonnes of CO_2 a year. Constraints such as feasibility, or only using renewable energy to power schemes, shrink that figure closer to around 5 to 10 billion tonnes a year. But that would still be a major contribution – 10 billion tonnes represents around a quarter of humanity's current annual carbon emissions. "It's massive," says Riebesell.

A pivotal report in December 2021 by the US National Academies of Sciences, Engineering, and Medicine (NASEM) called for multimillion-dollar research programmes into how ocean-based CO_2 removal might be done safely and without unintended negative consequences. For the moment, those do remain multimillion-dollar questions.

One obvious method would be the equivalent of afforestation on land: restoring natural carbon sinks such as kelp forests, seagrass and mangroves (see "Greening the blue", page 48). But their potential is probably limited, hence the interest in engineering approaches.

One of the original ideas is iron fertilisation. It involves seeding areas of the ocean with iron, a key nutrient that stimulates the growth of carbon-absorbing phytoplankton on the ocean surface. The idea is fish and other organisms eat the plankton and lock the carbon away in the ocean's depths when they die and sink to the bottom. At least 13 experiments using iron have taken place since 1993. Andreas Oschlies, a GEOMAR researcher who is one of the committee members behind the NASEM report, says it is the method that researchers have the most field experience with. Despite some initial signs that it could be effective, it has had "mixed success", he says. The image of the technique has also been tarnished after a 2012 large-scale test off Canada was accused of disregarding international treaties on the dumping of material at sea.

This is where David King, a chemist at the University of Cambridge and a former chief scientific adviser to the UK government, and his artificial whale poo come in. Now chair of the independent Climate Crisis Advisory Group, his idea is to emulate the natural role played by whales defecating near the ocean surface, which releases nutrients such as phosphorus and nitrogen that once again stimulate phytoplankton growth. The NASEM report was "a game changer", he says, with › several universities afterwards joining his group of institutes working on the synthetic whale faeces idea. The first small-scale field trials took place off the coast of Goa, India, in April and May. Depending on the results, further field trials will take place in the northern Pacific Ocean and the Southern Ocean.

It isn't the first experiment of its kind. An Australian team called WhaleX deposited a mix of nutrients off the coast of Sydney in December and is planning bigger demonstrations. Similar ideas include "artificial upwelling", using pipes to bring nutrient-rich water from the ocean depths to the surface, again to create phytoplankton blooms. Tests have taken place in a bay off Gran Canaria, a Spanish island in the Atlantic, but the idea is still largely conceptual and the NASEM report indicated low confidence in its ability to remove carbon and scale up.

The big objection to all these schemes is the possibility of negative environmental side effects. Creating phytoplankton blooms reduces oxygen availability and affects light penetration into the ocean, impacting the animals that live there, says Lebling. Deoxygenation, fuelled by warming and the effects of pollutant run-off from land, is an ongoing trend in the oceans, and anything exacerbating it would be bad news.

That is one reason much current ocean CO_2 removal research is focusing on a different technique, known as ocean alkalinity enhancement. Large-scale meddling to change the pH value of the oceans might instinctively make us squeamish, but we are already doing it. For more than a century, the oceans have been absorbing much of the CO_2 that humanity's factories and cars have pumped into the air. When this dissolves in seawater, it creates carbonic acid, increasing overall acidity.

Increasing acidity not only diminishes the ability of the oceans to draw down further CO_2, but also reduces how fast organisms from corals to mussels to zooplankton can use calcium and carbonate to build their shells and skeletons, and in the worse cases speeds up how quickly those protective structures dissolve. The net effect is to harm the entire food web above them, including us, and in the case of coral reefs to undermine their ability to act as a buffer against climate change impacts such as greater coastal flooding.

Alkalinity enhancement aims to reverse these trends, either through adding alkaline minerals to seawater or running an electric current through it to split the water into basic and acidic ions, then removing the acidic stuff. This approach is attractive because it could store carbon for a long time in the water and is scalable, says Riebesell.

Sea change

The technology hasn't yet been tested on a large scale, says Lebling. But it recently acquired a high-profile and wealthy backer. In January, Mike Schroepfer, a senior fellow at Meta (formerly Facebook), launched a $100 million side project called the Ocean Alkalinity Enhancement R&D Program to look at tweaking ocean pH. "This may be one of the most promising pathways for capturing carbon and turning back the clock on the damage we've done to the planet," he tweeted. The project has three pillars: one awarding funding for research, a second backing technology prototypes for small-scale deployment and a final one supporting research and engineering teams, such as helping them obtain permits for field studies.

In theory, enhancing ocean alkalinity should be relatively benign, says Riebesell: you are just turning back the dial on acidification, and you can do it in a controlled way. "If you could spread it nicely over a large area of the ocean, the likely environment impact is extremely small," he says. The problem is that that isn't how it works in reality: the alkaline materials

Greening the blue

Is there a "natural" way to enhance the potential of the oceans to lock away climate-warming CO_2? Planting more trees on land can help draw down more CO_2 from the atmosphere – the basis of many schemes for carbon credits that companies buy to offset their emissions. Something similar might work in the oceans, by stimulating the growth of marine and coastal ecosystems such as kelp forests, mangroves and salt marshes.

Some regard the potential for this "blue carbon" as huge, although as yet there is no mechanism for integrating it into carbon offsetting schemes. "It's really hard to turn blue carbon conservation and restoration into carbon credits that you can sell," says John Virdin of Duke University in North Carolina. "You have to go out and measure all the carbon that's there, you have to show that it's not going to be lost, you have to keep monitoring it." Virdin and others have proposed extending an existing land-based scheme called REDD+ (reducing emissions from deforestation and forest degradation) to the ocean, but that is an idea whose ship has yet to sail.

There is still some doubt about how big the marine offsetting effect might be. In March, the UK government's climate adviser, the Climate Change Committee, found that restoring and creating seagrass and saltmarsh ecosystems in the country would only sequester a small amount of CO_2, removing "well below" 1 million tonnes a year. Nonetheless, the committee said these are efficient carbon stores and conserving them is important given how much fishing and other activities have degraded them.

Restoring seagrass will sequester more carbon, but not a huge amount

ALEX MUSTARD/NATUREPL

ULF RIEBESELL/GEOMAR

Left: Alkalinity enhancement experiments in Gran Canaria, Spain.
Right: Field trials for stimulating phytoplankton growth off the coast of Goa, India

DAMODAR M. SHENOY

DAMODAR M. SHENOY

> "In theory, enhancing alkalinity to reverse ocean acidification should be relatively benign"

you are loading into the ocean will always come from a localised point source, such as a ship, and negative impacts are likely at that point, says Riebesell. These could include reducing plankton that fish rely on or physiological impacts on other marine organisms.

One encouraging sign is that in a yet-to-be-published study conducted last autumn off Gran Canaria, Riebesell and his colleagues found no biological impacts from changing the alkalinity of seawater in nine floating "mesocosm" bags, enclosed chambers that reflect the wider natural environment. In May, he started further tests south of Bergen, Norway, that will try out different mineral types, one silicate and one carbonate-based, in coastal waters. The location is near Europe's largest mine for olivine, a silicate mineral considered a leading candidate for making oceans more alkaline.

Myriad practical and technical challenges could still pop up. Alkalinity enhancement using minerals would require about 3 to 4 tonnes of material per tonne of CO_2 removed, meaning a global scale project would require effectively doubling existing operations to mine the minerals involved, says Riebesell. The scale of that effort would be "mind-blowing", he says.

Meanwhile, some unresolved questions dog all proposed ocean engineering schemes. One is who decides if activity such as alkalinity enhancement and nutrient boosting can take place. Most visions for such forms of ocean carbon capture are for the lightly regulated high seas, outside of the more tightly controlled Exclusive Economic Zones around the coasts of countries. "On the governance side, the biggest issue is there isn't an explicit framework for carbon removals," says Lebling. Some approaches could fall under two international treaties, the United Nations Convention on the Law of the Sea (UNCLOS) and the London Convention on the dumping of materials at sea.

These have already been invoked in the case of iron fertilisation, though an amendment to the London Convention means it doesn't block research projects. Moreover, they aren't universal. Some countries that are actively exploring ocean-based carbon removal aren't fully signed up: the US hasn't ratified UNCLOS, for example. Muddying matters further, countries signed up to the Convention on Biological Diversity have passed a series of relevant non-binding resolutions, including one in 2008 saying iron fertilisation projects should be avoided unless scientifically justified. Lebling says there is disagreement over whether those existing frameworks can be amended, or whether an entirely new treaty on ocean-based CO_2 removal is needed. That means governance can seem a "very daunting problem", she says.

Riebesell thinks public attitudes could be a barrier, too. "People have this gut feeling the ocean is pristine. We know it's not. We're messing with it every day," he says. Lebling also thinks public perception could be a challenge. Among researchers, there is also a concern that private start-ups seeking a quick return may rush things, or be inclined to ignore negative research findings about side effects. One fear is a cowboy company ploughing ahead too fast with the likes of ocean alkalinity enhancement and triggering a backlash.

Equally, there is a risk of going too slow and never scaling projects up. The debate on governance in particular "needs to move a bit faster", says Mar Fernández-Méndez at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany.

Riebesell says society needs to start weighing up the threats posed by extreme weather and unchecked global warming against the risks of ocean-based carbon removal. "At some point, climate change and the negative effects of that will be so obvious to our societies that we'll be more willing to properly compare the relative risks," he says. "Let's not look at risks in isolation. Doing nothing is not an option any longer." ▮

Adam Vaughan is chief reporter for *New Scientist*

New Scientist

Diversity Internship

Learn to be a science journalist

New Scientist is the world's most popular weekly science and technology magazine. Founded in 1956 for "all those interested in scientific discovery and its social consequences", the publication's journalists cover international news from a scientific standpoint and ask the biggest-picture questions about life, the universe and what it means to be human.

These fundamental mysteries are of interest to everyone, whatever their background. But both science and journalism suffer from a lack of diversity, with many talented individuals and valuable perspectives excluded or lost from these fields.

To address this, *New Scientist* is offering a learning and development opportunity open to anyone from an ethnic minority background.

Successful applicants will begin a six-month internship in October 2022. The internship will pay the 2022 London Living Wage and be based in our High Street Kensington office, London.

This year, we are recruiting two news interns and one video intern. News interns will receive one-to-one mentoring from an experienced journalist and on-the-job training in news and features writing, plus subediting and audience engagement, with your work published both online and in print. You will leave the internship with a portfolio of published work, ready to start a career in science journalism – as many of our interns have done.

Our video intern will be based in our video team and will learn how to produce scientific videos from idea to publication. You will source footage from researchers, script and edit short-form news videos and publish them across our online and social media platforms. Alongside this you will have the opportunity to come with us on shoots and be trained in camerawork. You will also receive foundational training in news writing and subediting, and will leave the internship with a showreel that demonstrates your skills.

The only entry requirements are that you will have completed a science, technology, engineering, mathematics or computing degree by the start of the internship, and that you have a demonstrable interest in writing, video editing or journalism.

How to apply

We ask applicants to submit 200 words explaining how they meet our requirements (see left) and why they are the right person for this internship. We also ask candidates to write an article, between 500 and 800 words long, on a recent scientific discovery, or create a 2 to 3-minute video on a scientific topic that interests them.

The closing date for applications is 8 July.

To apply, please visit tinyurl.com/nsinternship2022

The internship is a positive action scheme, under the Equality Act 2010.

M-IMAGEPHOTOGRAPHY/ISTOCK

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p53

***Almost* the last word**
Why do small children prefer to run than walk? p54

Tom Gauld for *New Scientist*
A cartoonist's take on the world p55

Feedback
Why you spend more money after drinking coffee p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

Citizen science

Join the bug splat count

Add a 'splatometer' to your car to help researchers track a worrying global decline in insect populations, says **Layal Liverpool**

Layal Liverpool is a science journalist based in Berlin. She believes everyone can be a scientist, including you. @layallivs

What you need

Access to the Bugs Matter app
A sampling grid, which will be sent to you by post when you sign up
A car or other road vehicle

HAVE you noticed a drop in the number of bugs splatted on your car windscreen in recent years? Researchers think this "windscreen phenomenon" is one indicator of a worrying global decline in insects, and your observations could help them to investigate the scale of the problem.

If you live and drive in the UK, you can get involved in this biodiversity research directly by participating in the Bugs Matter project this summer. You will need a "splatometer" – a sampling grid that you can stick to the number plate of your vehicle. This will be posted to you when you sign up to the project via the Bugs Matter smartphone app.

To start your experiment, simply wipe down your number plate before making your journey. Once you have arrived, count any bugs squashed on the plate using your "splatometer" to guide you. Then, take a photo of your observation and submit it via the app, along with information about the distance travelled. This will allow the Bugs Matter team to work out the number of "splats per mile".

Even if you don't spot any bugs on your number plate, you should still submit your observation as a count of zero. This information is just as valuable for monitoring changes in insect populations across the country.

CBCK-CHRISTINE/ALAMY

Observations made by volunteers who participated in Bugs Matter between 2004 and 2021 suggest that the number of flying insects splatted on cars in the UK fell by almost 60 per cent over this time period. This finding is consistent with other studies reporting declines in insect populations around the world.

A 2019 review published in the journal *Biological Conservation* identified habitat loss, pollution, diseases and climate change as key contributors to the global decline in insects. The same review found that more than 40 per cent of insect species could face extinction in the next few decades, with butterflies, bees and dung beetles among those at greatest risk.

The Bugs Matter survey is conducted annually during the summer to help researchers get a grip on year-to-year variation in insect populations. This year's bug count started on 1 June and is running until 31 August. Visit buglife.org.uk and search for "Bugs Matter" to learn more.

If you live in the UK but don't drive, you can still contribute to insect-related research this summer by participating in the Big Butterfly Count between 15 July and 7 August (I wrote about this project in a previous column). Butterfly enthusiasts based in Central America, North America or the Caribbean can record butterfly sightings through the eButterfly project. There are also plenty of apps that allow you to record observations of wildlife wherever you are.

Happy bug spotting! ▮

Citizen science is taking a break until September

Next week

Science of cooking

These articles are posted each week at newscientist.com/maker

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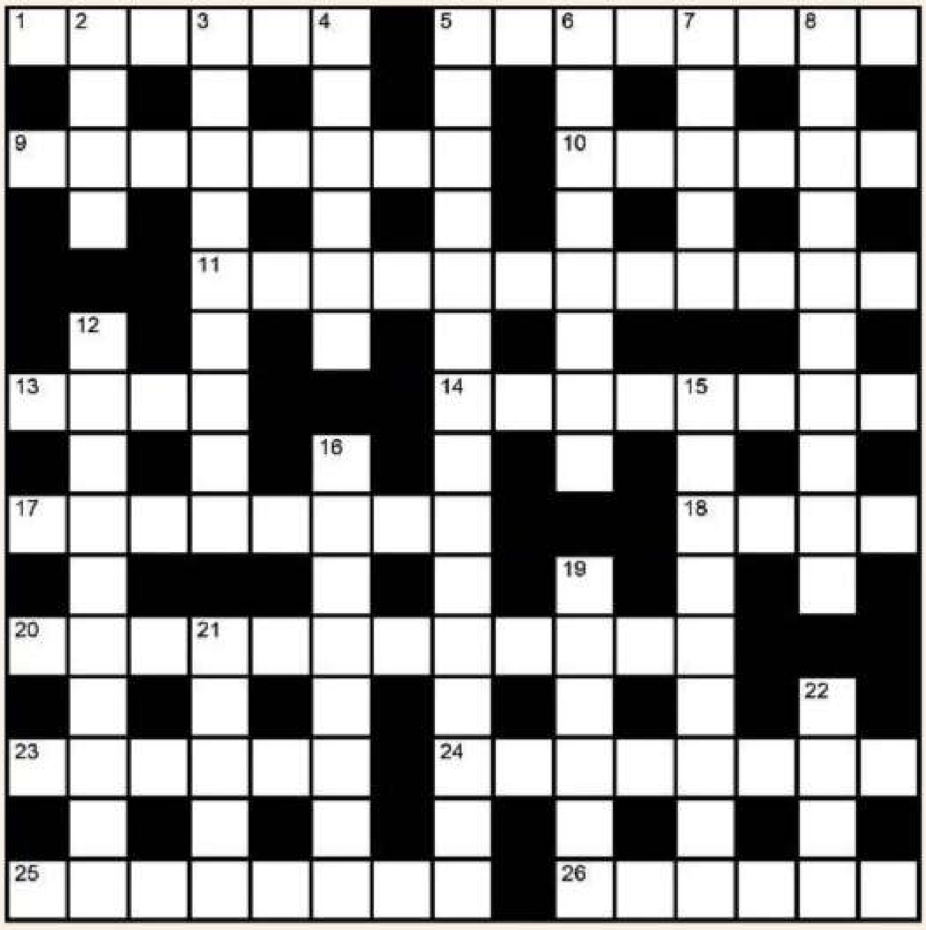
Quick crossword #111 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 ___ fibrosis, genetic disorder of the lungs and other organs (6)
5 Connecting (an electric circuit) to the ground (8)
9 Foundational level; starting point (8)
10 Recycled wool product (6)
11 Child born as a result of IVF, informally (4-4,4)
13 Form of inflammatory arthritis (4)
14 Relating to a period of fertility, in animals (8)
17 The study of serum (8)
18 Ill; vomit (4)
20 Electric guitar model designed in the 1950s (12)
23 Outer atmosphere of the sun (6)
24 Atoms with the same atomic numbers but different nucleon numbers (8)
25 1989 sci-fi film directed by James Cameron (3,5)
26 Listening device (6)

DOWN

2 Orbital period (4)
3 Eighth semiprime (6-3)
4 X-shaped structure made by crossing fibres (6)
5 Study of the movement and interaction of electric currents (15)
6 Shrub in the genus *Rosa* (4,4)
7 Thermonuclear weapon (1-4)
8 Soft-bodied marine gastropod (10)
12 19th-century German bacteriologist (6,4)
15 Human-made water resource (9)
16 Relating to the vessels that surround the heart (8)
19 Lamp that produces rapidly flashing light (6)
21 Scent (5)
22 Humped cattle (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #158

1 Siphonophores are colonial organisms that are each made up of several genetically identical animals. What are these individual organisms known as?

2 In what year was the last solar maximum, the period in which the sun is most active?

3 What name is given to a widespread, straight-line storm with destructive winds, often associated with the US?

4 Where in the human body would you find the canthi?

5 The extinct shark *Megalodon*'s name translates to what?

Answers on page 55

Puzzle

set by Chris Tiernan

#174 Pieces of eight

ROMAN PRYSIAZHNIUK/GETTY IMAGES

I have a 12-hour digital number display alarm clock. As is normal on digital clocks, each of its four digits is constructed using seven possible segments.

I go to bed when the display is at its dimmest and awake when it is at its brightest.

How long am I in bed?

Solution next week

Nippy nippers

Why do little children run everywhere instead of walking? Is it a legacy of sabre-toothed predators?

John O'Connell *via Facebook*
If I remember correctly, it was for the sheer joy of it.

Ton Smit
Utrecht, The Netherlands
The running of children has nothing to do with predators. It is the joy of life that each one of us would have were it not for self-consciousness, apprehension, worry, shame and, of course, the fatigue we all experience as we get older.

@Holten *via Twitter*
Children experience time differently than adults do. A year to them, between Christmases, is like a geological era because the interval is a substantial fraction of their lifetime so far.

Hence, not hurrying to their next goal risks the onset of boredom, which is a travesty for a child.

> **"Not hurrying to their next goal, and walking instead of running, risks the onset of boredom, which is a travesty for a child"**

@pramaan_dev *via Twitter*
Their running is a legacy of their hunter ancestors. Humans evolved as runners.

@LoneWolf907 *via Twitter*
No mystery. Children have all the energy adults wish they still had. I remember waking up in the morning with so much energy I just had to go outside and run.

n@ks2736 *via Twitter*
I used to run everywhere when I was a kid, never walked, I thought it was odd that everyone else walked.

Pomeranians came from wolves, so could they be bred back to their lupine form?

SHUTTERRUNNER/MATTY WOLIN/GETTY IMAGES

This week's new questions

Re-wolfing **Dogs are selectively bred from wolves, so could a Pomeranian, for example, be bred to be like a wolf?** ***Conrad Jones****, Cynwyl Elfed, Carmarthenshire, UK*

Wrong odds **Why does an even number feel "right" but an odd one "wrong" when, say, I'm setting my TV volume control? Am I alone in this?** ***Robert Morley****, London, UK*

@snsul_spirit *via Twitter*
I'm 32. I still like to run everywhere and cut corners like a running back.

Karen Packham *via Facebook*
Children run everywhere because they are still learning and refining their gross motor skills. Subconsciously, they are strengthening their bones and improving their coordination.

@RogerCordiner *via Twitter*
It is due to the need to keep up with adults, especially in the past in dangerous situations.

Eddie Stevenson-Kaatsch
via Facebook
Running is more exciting. Can't you remember anything from when you were little?

Complex conundrum

It is often stated that the human brain is the most complex object in the universe, but is it more complex than, say, Earth's biosphere? And how can this complexity be measured?

Herman D'Hondt
Sydney, Australia
As the biosphere contains, at last count, more than 7.9 billion human brains, we can confidently state that the biosphere as an object is at least 7.9 billion times more complex than a brain.

Garry Trethewey
Cherryville, South Australia
This claim has occasionally been made in articles and letters in *New Scientist*. A reader, Guy Cox, pointed out that a human body containing a brain must be a more complex object than just a brain.

This suggested the possibility of some sort of density component when measuring complexity. For example, is a pair of computers more complex than a single one, because of the number of parts present, or is it the same because the number of parts per computer is the same?

Is the complexity of a biosphere a function of the number of parts, such as human brains, birds' feet or tree leaves, or does that have to be divided by, perhaps, volume, or the number of entities?

Hillary Shaw
Newport, Shropshire, UK
The complexity of a system might be measured by the minimum incompressible information needed to describe it. However, perhaps we should also divide by space occupied, so complexity is now minimum information compressed per cubic centimetre, so "minimum information content per unit of space".

The London road network is surely more complex than the much sparser British road network, even though London roads are a subset of British roads. Without dividing by the space occupied, the biosphere must be more complex than the human brain, as the latter is a tiny part of the former. However, the biosphere is probably a lot more repetitive in content than the human brain is, so its descriptive information could be compressed a lot.

Some elements of the human brain do repeat, for example glial cells, but I'd still go for the human brain on this information/space basis.

Mike Follows
Sutton Coldfield, West Midlands, UK
The notion that the human brain is the most complex object

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Tom Gauld
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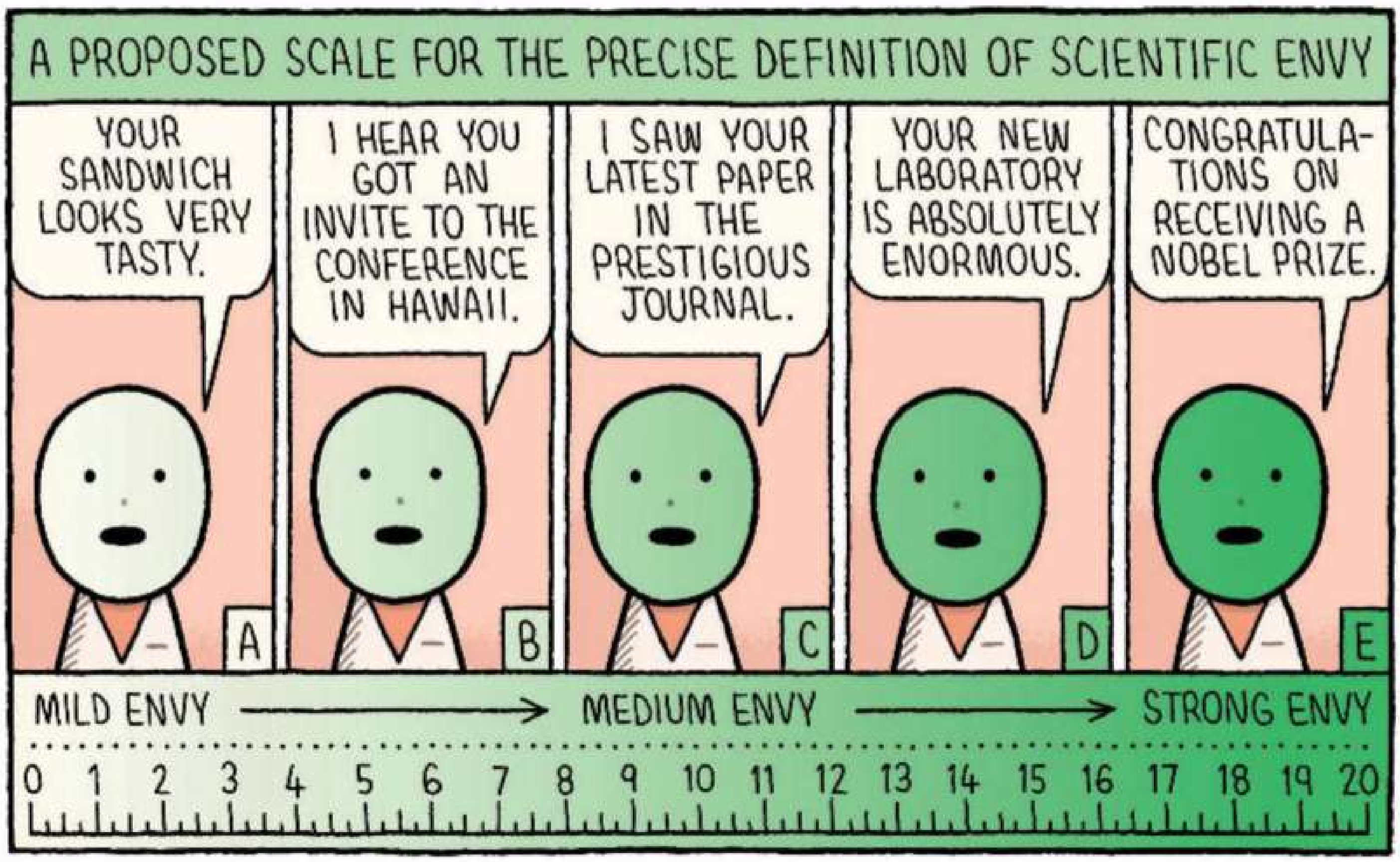

A PROPOSED SCALE FOR THE PRECISE DEFINITION OF SCIENTIFIC ENVY
YOUR SANDWICH LOOKS VERY TASTY.
A
I HEAR YOU GOT AN INVITE TO THE CONFERENCE IN HAWAII.
B
I SAW YOUR LATEST PAPER IN THE PRESTIGIOUS JOURNAL.
C
YOUR NEW LABORATORY IS ABSOLUTELY ENORMOUS.
D
CONGRATULATIONS ON RECEIVING A NOBEL PRIZE.
E
MILD ENVY → MEDIUM ENVY → STRONG ENVY
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

in the universe smacks of anthropocentrism. Surely the brain is less complex than the body that accommodates it. Besides, other animals, like blue whales, have bigger brains than ours.

A brain is certainly more complex than a digital computer. The CPU (central processing unit) chip in a computer typically has 2 billion gates. Each gate can be set to just one of two values (0 or 1) and connected to only a handful of other gates.

In contrast, the human brain has neurons instead of gates and about 40 times as many of them. They are interconnected in myriad ways and each one acts like an analogue device that can be set to a wide range of values. But surely the human brain meets its match with the internet, or will in the future.

Complexity can be defined as an emergent property of systems that follow simple rules. An example of this can be seen in a starling murmuration or schooling fish. Each creature is "programmed" to avoid a collision by maintaining a minimum distance from its neighbours, yet this simple rule leads to startling patterns.

> **"Surely the human brain is less complex than the body that accomodates it. Also, the brains of blue whales are bigger"**

The universe began with the big bang, and has certainly developed to become ever more complex. However, the brain is the only object known to have produced self-awareness and this might be what sets it apart from other objects.

Martin Murray
Telford, Shropshire, UK

I have long found this statement annoying. It sounds sciencey, but is totally meaningless. An object is a mental construct that exists only in the brain. It is how we divide the universe into bite-sized chunks so that it is digestible.

We can define the human brain as an object and come up with a measurement of complexity. The whole human being can also be an object and obviously more complex. A collection of humans could be an object (parliament, Congress, UN general assembly) and the whole planet of several billion brains can be an object.

If you take out the random mental constructs, the universe is entirely composed of subatomic particles interacting with all the other particles according to the same physical laws and thus everything is equally complex.

Statements like "the brain is the most complex known object in the universe" might be useful for grabbing a headline and landing a bit of research funding, but I don't think they are much use otherwise. I don't think nature plays Top Trumps.

A more relevant question would be: is the human brain complex enough to avoid self-extinction, or are all evolved apex intelligences doomed to wipe themselves out? That one isn't looking good for the human brain right now. ▮

Answers

Quick quiz #158 *Answers*

1 Zooids
2 2014
3 Derecho
4 The eye – they are the corners where your eyelids meet
5 "Big tooth"

Cryptic crossword #86 *Answers*

ACROSS 1 Plank, **4** Leap day, **8** Eat into, **9** Stria, **10** Curettes, **11** Kiln, **13** Decoct, **15** Sneeze, **18** Dill, **19** Fire trap, **22** Twirl, **23** Elastin, **24** Rotator, **25** Moose

DOWN 1 Pierced, **2** Attar, **3** Kinetics, **4** Looker, **5** Also, **6** Dormice, **7** Yearn, **12** Underarm, **14** Cellist, **16** Expanse, **17** Linear, **18** Deter, **20** Ratio, **21** Plot

#173 Knight moves *Solution*

Knight 618, Bishop 591.

Call the knight's numbers BCD and ABCD, and the bishop's numbers XYZ and AXYZ. Number AB must be different from AX because the knight and bishop can't type the same consecutive digits. This means YZ must be high enough that adding 27 increases the hundreds digit. Since there is no zero on this number pad, the only option is that Y = 8 or 9 and C = 1. Since C = 1, B and D must be either 6 or 8, the two numbers we can reach from 1 in a knight move. This gives us four possibilities to check: 616, 618, 816 and 818. Subtracting 27 from each of them, we find 618 – 27 = 591 is the only number that can be made by a bishop. I could also put a 1 or a 7 at the front to make the knight numbers 1618 or 7618, both 27 more than a bishop number.

On the scent

It turns out that drinking coffee will unlock Feedback's wallet faster than rumours of a hot new crypto offering. A study in the *Journal of Marketing* reports that consuming a caffeinated drink before shopping gets us to spend one-and-a-half times the amount we would have done had we chosen decaffeinated coffee or water instead. Lead author Dipayan Biswas at the University of South Florida blames the dopamine released as a result of the stimulant, which in turn boosts impulsivity, lowers self-control and (quite specifically) sends the sale of scented candles (see page 16) rocketing.

Internet bubbles

Alas, this insight came too late for Feedback, who may have overdone the stationery cupboard facelift. Should scented candles be shelved under "S" or "C"? And was it really necessary to buy a hot tub that connects to the mobile network? Of course it was, says SmartTub, a Jacuzzi brand whose gewgaws allow you to set the jets, lights and temperature of your bath when you are out of the room.

The downside to this (beyond implying you aren't around to enjoy your own bath) is a familiar one: security. Ethical hacker EatonWorks stumbled on multiple weaknesses on the SmartTub site (which have since been, er, plugged). "As for remotely controlling tubs," EatonWorks assured readers of the Motherboard website, "I think the worst you could probably do is turn the heat all the way up." As we write this, Jacuzzi had yet to comment on the leak. (Sorry.)

When words don't count

A more pressing problem is how we are going to afford this blessed thing. Feedback's go-to solution – write a bestseller from within the tub – shrivelled after spotting Marc Abrahams's analysis of a recent paper in the *Open Journal of Statistics*. Emilio Matricciani's "The Temporal Making of a Great Literary Corpus by a XX-Century Mystic: Statistics of daily words and writing time" captures, as few more critical works have ever captured, the sheer labour involved in setting words down on paper.

Twisteddoodles *for New Scientist*

SCIENCE UNICORN
JUST DISCOVERED THAT HE DOESN'T EXIST
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT
Consideration of items sent in the post will be delayed

Between 1943 and 1951, Maria Valtorta, an Italian mystic who was confined to bed, wrote about 2.64 million words in notebooks, dating every entry. Matricciani has calculated that Valtorta, armed "with a set of fountain pens always filled with ink because she did not know when the alleged visions would come", wrote for the equivalent of 1340 days – or about 3.67 years of constant writing.

What he doesn't mention is that Valtorta's four-volume *The Poem of the Man-God* was placed on the List of Forbidden Books; the Vatican called it "a badly fictionalised life of Jesus... written rather inappropriately and recalling certain descriptions and scenes from modern romance novels". Some writers can't get a break.

Lost in translation

We could automate the creative process, of course – though experiments in that line are getting creepier by the day. *The Sun* newspaper reports that DALL-E 2, the latest AI system from OpenAI, can not only generate images from prompts (like, say, "Two people talking about vegetables, with subtitles"), it will also describe that image back to us in a (fairly) stable language it has invented.

Giannis Daras and Alexandros Dimakis at the University of Texas at Austin have begun to decode this modern Rosetta Stone. When DALL-E 2 talks about "vicootes", it means vegetables, while birds are "apoploe vesrreaitais" – which is a little too Lovecraftian for comfort.

One-way trip

With a shudder, therefore, we turn from literary endeavour to more reliable means of earning money. Are we willing to have cockroaches run riot in our house for a month? asks The Pest Informer, a US pest control and media company. For a $2000 consideration, we jolly well are. But so were 2500 others, all rushing to apply for just half a dozen opportunities. So that's out.

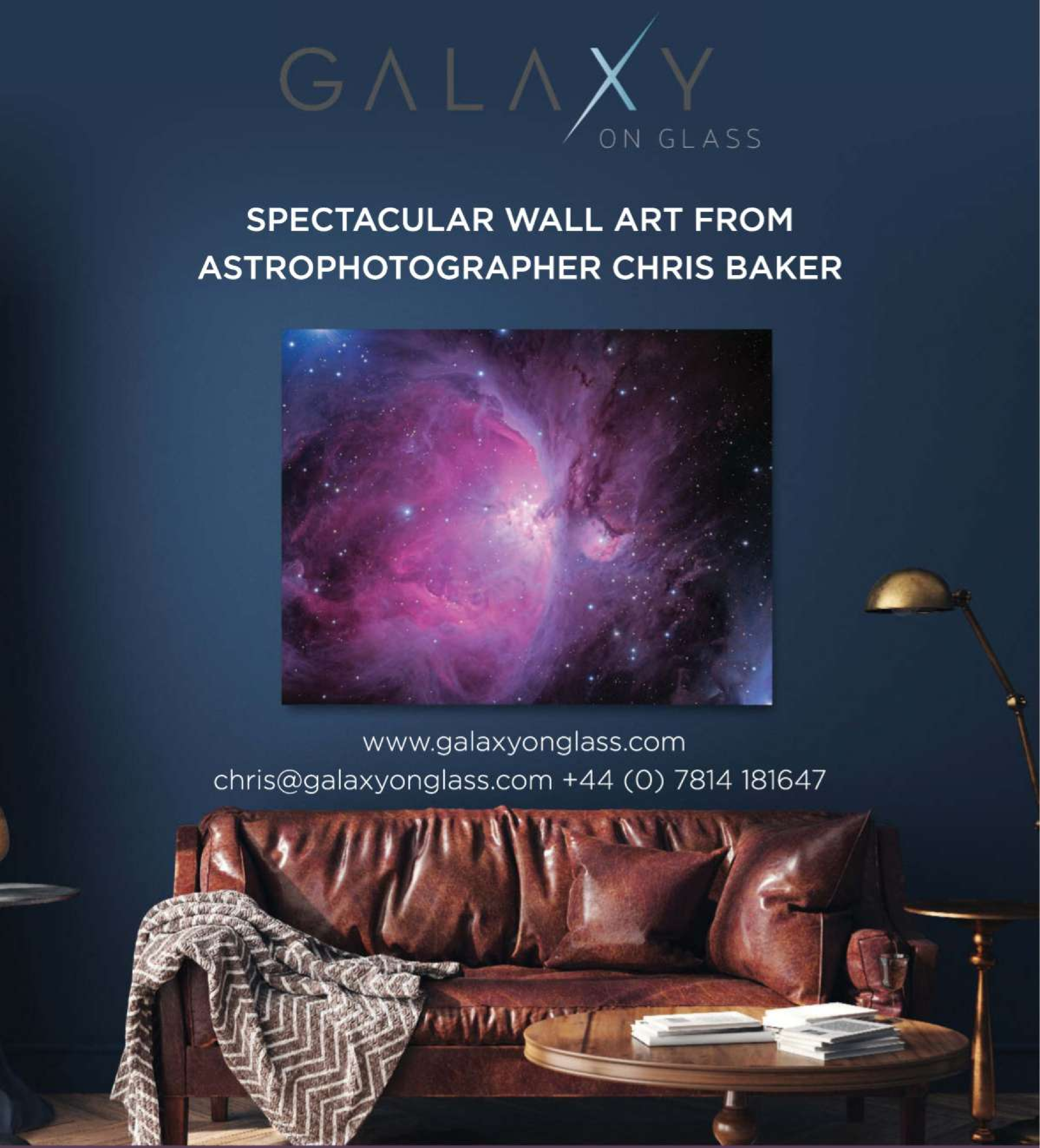
The cockroaches' Airbnb-like experience will not, in any case, end happily. The Pest Informer will be testing out extermination techniques. So it is with empty pockets, but a clear conscience, that Feedback settles back and glances through the mail, while that barely affordable hot tub hots up.

A little too steamy

In light of our hunt for words for anti-expert, Chris Arnold recalls his father's stint as an educator in the 1960s in what is now Eswatini, but was then a British colony. This involved fielding a great many learned visitors from his home country. His local colleagues very quickly established a definition for an expert as "an ordinary person from very far away".

Quick check of the phone app... This tub is taking an inordinate amount of time to heat up, but, meanwhile, reader Peter Calver reckons the opposite of expert is "polymyth" – a simple yet endearing conceit. David Evans lowers the tone with news that the Royal Liverpool Philharmonic Orchestra has a timpanist called Neil Hitt...

Ah, and with a ping of the app, we are set free! Off with the jodhpurs and the Christmas cardigan. My it's steamy in here. Too steamy by half, I reckon, and – GOOD GRIEF, what kind of temperature is this?! You could poach a flock of apoploe vesrreaitais in here. ▮



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